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Cover picture: Blue wildebeest and Chapman's zebra at a watering hole in the Transvaal.

AFRICAN WILD LIFE AS A PROTEIN RESOURC

The subject of wild-life management and utilisation is now of such importance that it is to be discussed at a high-level conference to be held at Arusha, Tanganyika, in September, 1961, under the auspices of FAO, the International Union for Conservation of Nature and the Commission de coopération technique pour l'Afrique au sud du Sahara. The author of the following article has spent considerable periods of ecological study in Africa, and last year he published a study made for the Game and Tsetse Control Department of Northern Rhodesia, under the title Wild Life in an African Territory (*Oxford University Press; 25s. in UK*).

Some years ago I went on a month's walk into a Central African valley during the wet season, with a colleague and 45 porters: it was an arduous expedition and I was interested in the behaviour of the men and the motives which led them to do this work for 1s. 2d. a day, all found. The key phrase was 'all found'.

These men were mostly of the Bisa tribe off the great African plateau which stretches from South Africa into Tanganyika and beyond. Their part of the plateau was of poor red soil and granite kopjes and seemingly endless poor forest and grassy swales or *dambos*. Livingstone crossed and recrossed that country and reported even then how scarce game was on the plateau; and there are no cattle either. All that country is overburnt each year, which practice degrades rather than helps the habitat. Our 45 porters were undoubtedly protein-starved but such is the innate physical strength of the African that they could take on carrying 50 lb. loads for 10-15 miles a day through rough country. Their hope and expectation was that we should provide all the meat they needed—*nyama*—by shooting game.

The porters were not disappointed: we were in a great tropical valley, roadless and with very few inhabitants. This was the old Africa, abounding in game of many species, elephant, buffalo, eland, roan antelope, waterbuck and a score more. Buffalo herds were large and well dispersed in this wet season and there was little trouble in giving the men all the meat they could eat. And how much could they eat! Not only were their immediate appetite and good spirits astonishing, but they were happy smoking the meat over the camp fires and did not mind carrying another 10 lb. of a load of lightly smoked

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Giraffe, Eldoret, Kenya. A species filling an obvious grazing niche.

meat. This seemed to give them a sense of well being.

Each night just before the evening meal a silent row of sufferers would appear and we would dispense 'surgery' for an hour: tropical ulcers, stomach aches, sore throats, endemic malaria and so on. Some of our 'cures' such as a tablespoonful of kerosene for sore throat were obviously effective because the sufferers never appeared the second night. Trust must have done a lot of good, but as an observer I felt that *vis medicatrix naturae* by way of steady exercise and a high protein diet was the real medicine. The men finished that month's walk in splendid condition, physically and mentally. I doubt whether the thirty shillings or so made much difference.

Protein Starvation

From this simple tale we have to ask why and how there should be protein starvation in Africa in an age when agricultural and nutritional science has made such immense strides forward. It was thought 30 years ago that the presence of the tsetse fly and trypanosomiasis was the main obstacle to the expansion of stockbreeding. The tsetse remains on over two million square miles of Africa but its status is much better understood now, and it is no longer the main obstacle. Therapeutic, administrative and ecological control of the fly can be extraordinarily effective, used together wisely.

But the realisation is gradually filtering through, even to the fanatically technological and the naively remote administrative mind, that the continent of Africa may not be necessarily a rich, ripe plum awaiting development. The extraordinary richness of a few areas, such as the cocoa and oil nut soils of West Africa, the Kikuyu Reserve and White Highlands in Kenya, the sugar cane soils of Mozambique and some of the delightful country round the Cape have blinded us to the fact that immense areas of Africa will not sustain an agriculture and a pastoral industry as usually understood.

A recent optimistic report on the possibilities of Africa stated ingenuously that when one considered the enormous numbers of hoofed animals which the continent earlier supported, it was obvious that stock raising must have a great future. This kind of thinking neglects analysis of the ecological situation as it was formerly and is now. Again, there must have been much disappointment among the optimistic sponsors when an FAO mission returned from the northern plateau region of Northern Rhodesia and reported realistically that the shifting *chitemene* cultivation as practised by a moderate or low population was probably

the best way of using the ground; and also that, as that country is not one of steep slopes, it was probably the most conserving method of cultivation—small 'gardens', three years in cultivation with the potash booster from burning, and 40 years to recover under the natural vegetation.

We are all aware that there are pockets of maize and tobacco soils in the Rhodesias, but they are only pockets in a large cloak. The White Highlands are quite inadequate to build a strong and continuing agricultural economy in Kenya. There are large areas of cattle ranching country in these territories, but the agronomist is aware that the ranches are often gravely deteriorated in stock-carrying capacity as compared with the numbers of wild game which formerly occupied the land.

Ecological Complex

The reasons for these phenomena lie in the ecological complex of climate, soil and the natural communities of plants and animals, and explanation lies in comprehension of some aspects of ecological theory: the very ancient soils of the plateau country are fragile, base-exchange conditions are poor and crumb structure is soon lost if the natural vegetation is removed. A climatic year of six months wet and six months dry means leaching and shortage of calcium in the surface layer, and such an extreme situation demands every natural safeguard of providing soil shelter and shade in order to prevent erosion and excessive evaporation.

That monotonous and seemingly endless *miombo* forest of the Rhodesias and much of Tanganyika looks to be a fairly rich production on initially poor soil. We find on examination that a large proportion of the large number of species of trees present is of the leguminous group, dominated by *Brachystegia-Isoberlinia*, *Piliostigma* and *Acacia*. Their roots go deep and their seeds are rich in vegetable protein. The pods of seeds are in general eagerly consumed by the wild game. The varied complex plant community is consumed in part by a varied complex community of animals.

The volcanic soils in Kenya and Tanganyika are subjected to an even drier climate. They are so porous and ill-adapted to holding water that disturbance of the natural vegetation is even more dangerous than on the old plateau soils. But here again there is a varied and beautifully integrated plant and animal community showing in nature a remarkable biological turnover.

Ecological theory suggests that in any set of climatic and geological conditions there tends to develop the most complex biological community which those conditions will allow, and that a complex community will show a greater rate of biological turnover than any simpler community on the same ground. This is a phenomenon of niche structure, of the intricate variety of things which plants and animals do. Unconscious cooperation between individuals and species in a biological community is much more apparent than the conventional notion of competition.

The highest possible rate of conversion of organic matter with minimum of loss is the true measure of wealth of a natural community, and of a region, but it has nothing to do with the economic efficiency with which man may tap that wealth for his own ends. It is an interesting observation that in using ground man has in general simplified the plant and animal communities; the historically minded may care to think through a host of human cultures in their habitats, and be surprised by the few that have been able to maintain initial wealth unimpaired. Fewer still have managed to improve on it. Leicestershire grass as compared with the former oak woodland is an example of successful deflection of ecological succession, and the favoured English and north-western European soils have been able to benefit from skill and hard work and, by the introduction of leguminous crops, to increase the rate of biological turnover. Such highly farmed soils will accept large dressings of chemical fertilisers without deterioration, and turnover is still further increased.

But simplification of fragile African habitats leads to deplorable impoverishment and diminution of what might be called the voltage of the conversion cycle. Protein as a crop is lost first, but starch of diminishing value can be produced for a long time. The bottom of the scale is represented by the potato in Ireland and the West Highlands in the early nineteenth century, and cassava in Africa today.

Many Hoofed Species

Africa, south of the Sahara, has been remarkable for the immense wealth of hoofed animals. The elephant is at the head as the great pathmaker, as a ploughman when he pulls over trees, and as a top browser, providing conditions for young growth at a lower level. The elephant by wallowing also creates water holes which may persist long enough to allow other ungulates, such as a variety of antelopes, to use the country for a longer time in the dry season. The rhinoceros eats a large quantity of young gall acacia, thereby preventing the country from becoming covered with sterile bush. Buffalo, eland, hippopotamus, kudu, impala, puku and many more species have their particular grazing and browsing niches leading to a full utilisation of habitat. The hippopotamus is the unerring drainage engineer for a river basin and provides his own heavy equipment.

It is this intricate stratification of function, this wide spectrum of species, which maintains the varied vegetational habitat without deterioration and sustains the voltage of the conversion cycle. The degradation of many ranching and nomadic pastoral areas in Africa shows the influence which simplification, for ease of cropping the narrowed spectrum of two or three domesticated animals, has had.

The new trend of thought is to conserve these fragile or brittle habitats by aligning ourselves with the natural order and being prepared to take our crop of meat from wild animals. The elephant is a thriving, colonising species and an adult yields three tons of meat. Buffalo are more difficult to crop, but it can be done; and hippopotamus are conveniently localised, gregarious and heavy yielding. Even the national parks are becoming aware of the necessity of managing and cropping the wild life within

them. Conservation of wild life in Africa would be much surer under a regime of controlled cropping.

Collection of Data

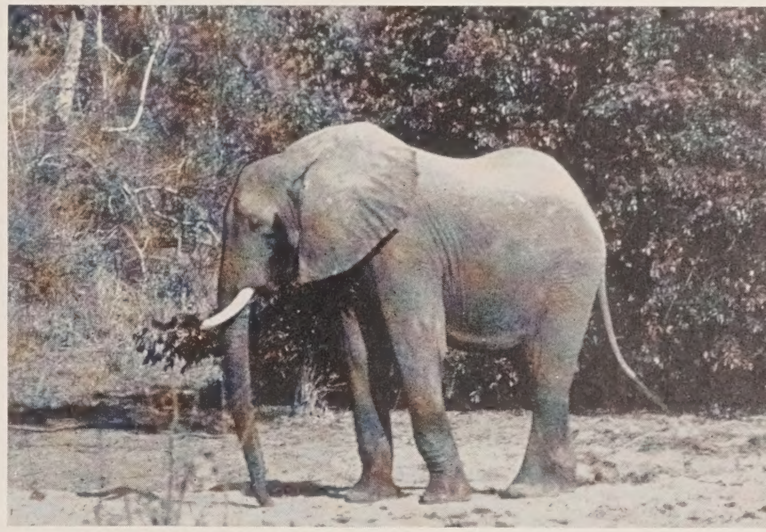
Of course, many of the data the sceptical critic would wish to have before him are not available: densities, life tables, migrations and so on. But at least such work is under way. Hugh Lamprey, an Oxford biologist attached to the Tanganyika Game Department, is refining methods of making censuses of bush animals. Bernard and Michael Grzymek have made censuses and vegetational studies on the Serengeti Plains. The American Fulbright scholars, Petrides, Swank, Buechner, Buss and Longhurst, have made valuable pioneer studies in East Africa. Longhurst's work on hippopotami has led to a steady policy of cropping these animals in Uganda. Three other Fulbright scholars have been working in Southern Rhodesia: Riney in collaboration with the Government, and Dazmann and Mossman in cooperation with a large ranching business. They have found that range for domestic stock is improved if there is a variety of game present and that the disease factor is quite secondary to this benefit. They also find that wild game kills out a better percentage than cattle under the same conditions. The meat is also better if given equal treatment.

Lee Talbot and his botanist wife, also Americans, are studying carrying capacity and protein yield in the Mara-Serengeti area along either side of the Kenya-Tanganyika border. Harthoorn, a veterinary physiologist in Uganda, on the staff of Makerere University College, is studying the metabolism of game species in comparison with known figures for domesticated stock. The author of this article has made several ecological reconnaissances in Africa and has given special attention to the reasons—of soil, climate and community structure—why a wide spectrum of wild animals can yield a higher crop of protein from marginal and submarginal lands in Africa than can ranching of domesticated stock solely.

Much work remains to be done before figures can be offered, and the human population explosion may render such work useless. The alternative is that Africa would bleed the rest of the world: but for how long? However, the idea is getting through and may result in the acceptance of certain animals as being the best utilisers of given habitats. For example, the densely gregarious red lechwe antelope in the flood plain of the Kafue River in Northern Rhodesia faces extermination unless it is realised that no other creature grazes the plains during inundation, and the lechwe has a higher potential protein-per-acre value than cattle. It is probable that orderly cropping will replace the indiscriminate mass hunts of the present. Again, the 300 elephants killed annually in the Luangwa Valley as a control operation are carefully used and provide more than half a pound a week for every man, woman and child of the 60,000 human population.

Management of the animals involves control of fire—a good servant and a bad master. Properly used, instead of in the wild manner of the present, fire can raise the degraded carrying capacity of the plateau soils to former ecological health.

Lions with a zebra carcass, Mara Plains, Kenya. The present predators are constructively selective.

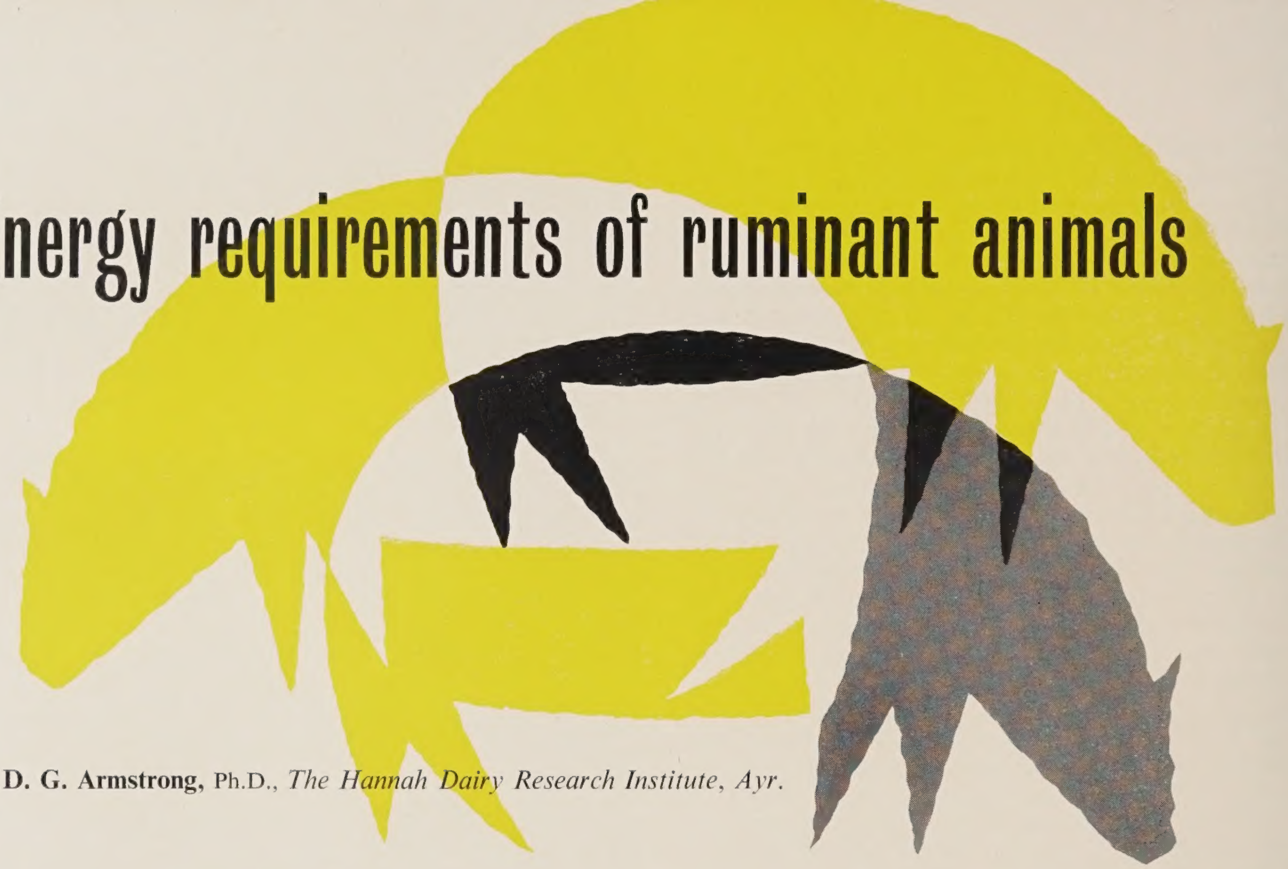


A bull elephant, Luangwa Valley. A key species in wild life management.

Hippopotamus, Albert Nile, Uganda. Gregarious and conveniently localised, hippopotami give a good yield of meat.

Wildebeeste, Nairobi National Park. One species in the spectrum of wild animals which can give a high yield of protein from marginal land in Africa.

Energy requirements of ruminant animals



by **D. G. Armstrong,** Ph.D., *The Hannah Dairy Research Institute, Ayr.*

The requirements of farm animals for energy and the extent to which different kinds of feeds can meet these requirements are of major importance to those concerned with livestock production. Quite apart from the considerable advances that may arise from knowledge of the fundamental processes by which the energy of vegetable foods is converted to that of livestock products, there is a very urgent need for the re-evaluation of the requirements for energy of farm livestock and the energy values of feedstuffs. Furthermore, the accurate determination of the nutritive value of a fodder is of importance not only in the rationing of animals, but also in assessing the value of new forage plants, new methods of forage conservation or improvements in harvesting techniques.

The researches made at the turn of the century by Kuhn, Kellner and their associates in Germany, and by Armsby and his co-workers in the United States, gave much useful information on the energy value of foods. Their data provided the basis for the starch equivalent system of feed evaluation which is in use today in many countries of the Commonwealth and in parts of Northern Europe. However, partly as a result of the increasing awareness of the importance of amino acids, trace elements and vitamins, and partly as a result of the technical difficulties involved in energy metabolism studies and their time-consuming nature, these basic studies were not extended in the years that followed. Indeed such was the position that in 1938, Orr and Leitch (1) wrote: 'In recent years research in nutrition has become so much absorbed in the study of the requirements for specific food constituents, and of the effects of deficiencies of these on health, that there is a danger that energy requirements may be regarded as being of minor importance. But however important the requirements for specific nutrients may be, the energy requirement is primary and, under ordinary conditions, will be satisfied before and even at the expense of any other'.

Today the position is very different and energy metabolism studies with farm livestock are in progress in many parts of the world—notably in Eastern and Western Europe, America, Japan and Australia. In the United Kingdom, research on energy metabolism has been done in the Nutrition Department of the Hannah Dairy Research Institute for some 12-13 years under the direction of Dr. K. L. Blaxter, and it is with some of these studies and their general implications that this article is concerned.

Energy Balance Study Methods

Before discussing the results of energy balance studies it is necessary to say something of the method by which such studies are made. Table 1 presents typical results for the partition of the daily energy intake by a fattening sheep.

The major losses of energy occur as heat and as the heat of combustion of the faeces. The energy lost in urine and as the combustible gas, methane, accounts for a further 12 per cent. of the total intake. The intake of energy less the sum of these four components of energy loss is the energy stored in the body as fat and protein. In order to determine the retention of energy the heat production of the animal and the amount of methane the animal produces must be measured and the energy contents of feed, faeces and urine determined.

One method of obtaining heat production and the methane energy loss is to house the animal in a closed-circuit respiration chamber and measure its oxygen con-

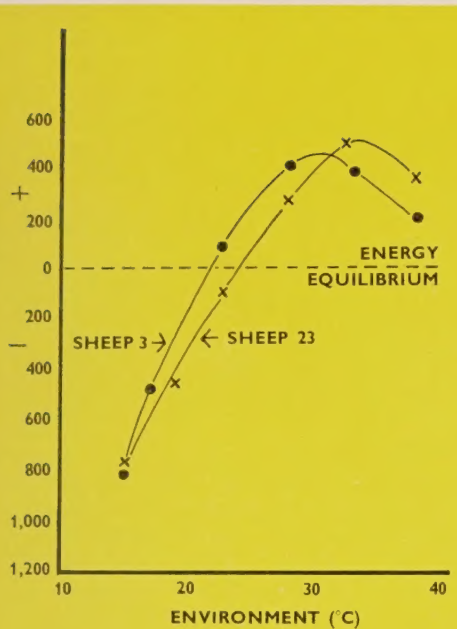


Fig. 1

Energy retention of two closely-clipped sheep at various environmental temperatures when receiving 1,200 g. dried grass in 24 hours.

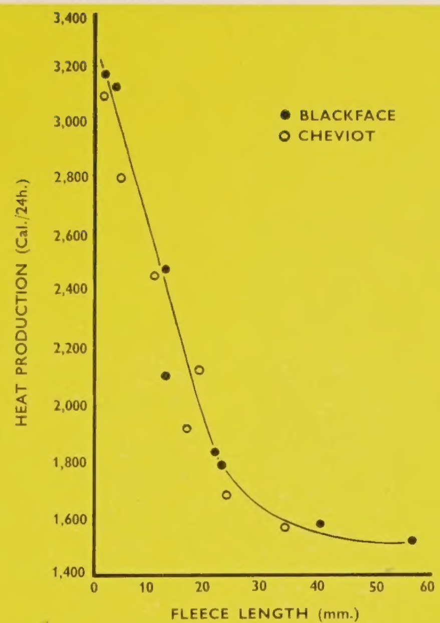


Fig. 2

Heat production of Cheviot and Blackface wether sheep determined during growth of the fleece. The environmental temperature was maintained at 8°C.

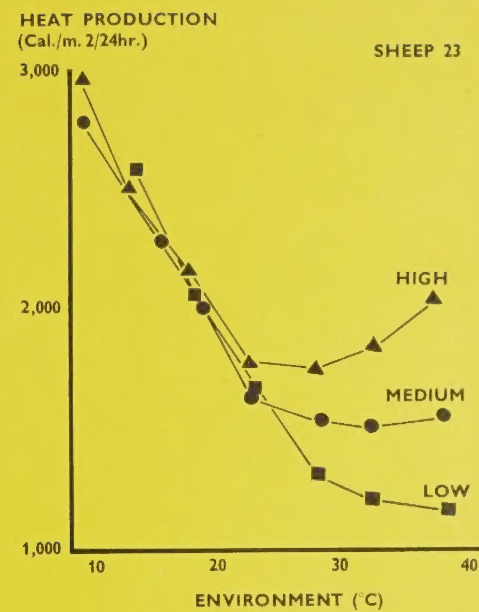


Fig. 3

Heat production of a sheep per square metre body surface at three feeding levels in relation to environmental temperature. Feeding levels: low, 600 g.; medium, 1,200 g.; high, 1,800 g. dried grass in 24 hours.

sumption and carbon dioxide and methane production. From these data and a knowledge of urinary nitrogen excretion the heat production of the animal can be computed by well-established and verified techniques.

At the Hannah Institute a relatively simple type of closed-circuit respiration apparatus for cattle and sheep has been developed in which control of temperature and humidity within the chamber is precise and each can be varied over a very considerable range. Experiments at this Institute have shown that the patterns of energy loss in maintenance and in fattening in sheep and cattle are remarkably similar.

The experimental studies made in the early stages of development of the laboratory were almost entirely devoted to delineation of the conditions under which measurements of the net energies of feeds could be made. They involved consideration of the effects of the amount of food given to the animal, the frequency of feeding, the physical form of the feed, and the environmental temperature within the respiration chamber on the amount of energy retained by the experimental animal. Some of these studies have a wider interest than simply the delineation of general conditions for the measurement of energy retention, as the following example shows.

Importance of Environmental Temperature

In calorimetric experiments designed to determine the

Table 1
Partition of feed energy in a sheep

	kcal	*% of total*
Daily intake	5537	100
Daily loss in		
faeces	1291	23.3
urine	271	4.9
methane	402	7.3
Daily loss as heat	2418	43.7
Daily balance stored in body (by difference)	1155	20.8

energy value of a food it is clearly necessary to ensure that the experimental animal is kept at all times within the zone of thermo-neutrality (defined as the range of temperature in which heat production is constant and minimal). The energy retentions of two closely-shorn sheep given a constant food intake at various environmental temperatures are shown in Figure 1. Minimal heat production, and hence maximal energy retention, occurred at temperatures of 25-32°C.; at temperatures lower than these the heat production of the animals increased markedly. There was also a rise in heat production, and therefore a fall in energy retention, at environmental temperatures higher than 35°C. Similar effects have been found with steers.

Two of the major factors which determine the zone of thermo-neutrality of a particular animal are the insulation against heat loss provided by the hair or fleece and the amount of heat to be dissipated, which is broadly proportional to the daily food intake.

The importance of fleece length in determining the level of heat production in sheep was confirmed in a series of experiments with Cheviot and Blackface sheep which had a constant food intake. These sheep were clipped at the beginning of the experiment and heat production measured at intervals thereafter as the fleece grew. The results obtained at an environmental temperature of 8°C. are shown in Figure 2; they show that minimal heat production occurred only when the fleece was approximately 4.5 cm. long.

The effect of environmental temperature on the heat production of a sheep receiving three different amounts of food is shown in Figure 3. The animal was shorn at weekly intervals throughout these experiments to keep the fleece short. It can be seen that: at the lowest feeding level the environmental temperature corresponding to minimal heat production was 38-40°C.; at the medium feeding level, 32-33°C.; and at the highest feeding level, 24-27°C. The lowest temperatures corresponding to minimal heat production are termed critical temperatures; it can be seen that the effect of increasing the food intake from 600 g. to 1,800 g. per 24 hours was to lower the critical temperature from 38-39°C. to 24-27°C. As the fleece or hair coat of an animal grows the critical temperature for a particular level of feed falls. This is well illustrated in Table 2, which shows the critical temperatures of Down cross sheep with fleeces of varying lengths when receiving 1,200 g. of food.

It must be remembered that the critical temperatures given in Table 2 relate to animals with dry fleeces and subjected to minimal air movement. Under natural conditions when, in addition to low environmental temperatures, there may be considerable rain and wind, the critical temperatures may well be higher, particularly if the fleece is short. Even in countries such as the United Kingdom, where shearing is generally delayed until the warmer months, shearing can, under certain conditions, result in loss of production. The numerous deaths in certain years reported among sheep stocks in Australia and New Zealand, where machine shearing is often done in late winter, are largely due to cold.

It has been noted that at temperatures higher than the critical temperature the heat production of sheep and cattle rises. The increases in heat production are associated with rises in rectal temperature and no doubt result from a general quickening of metabolism as a result of difficulties in heat loss and consequent rise in deep-body temperature. Such effects must have important implications with regard to levels of intake and efficiencies of food conversion in livestock kept in tropical countries.

While these experiments were made to find under what conditions energy retention could be regarded as a reflection of the food given rather than of the animal's reaction to its environment, the results clearly have a wider applicability to farming practice. In particular they have a bearing on the management of shorn sheep and the protection of both sheep and cattle from the effects of climatic extremes.

Net Energy Value Experiments

Experiments to determine the net energy values of various species of grass, of hays, and of hay and concentrate mixtures are in progress. In addition, more fundamental studies on particular aspects of energy metabolism are being made. One of them, on the utilisation of the energy of carbohydrates for fattening by ruminants, is described below.

The amount of energy of a food available within the body is termed metabolisable energy and is measured as the energy intake less the sum of the losses of energy in faeces, urine and as methane. Only a portion of this metabolisable energy is capable of being used by the animal for useful work or storage as body tissue, considerable

Table 2

Critical temperatures of Down cross sheep with fleeces of various thickness when given 1,200 g. dried grass daily

Fleece thickness (cm.)	*Critical temperature (°C.)*
0.1	27
0.1	28
2.5	13
4.0	11
4.5	8
10.0	5
12.0	0

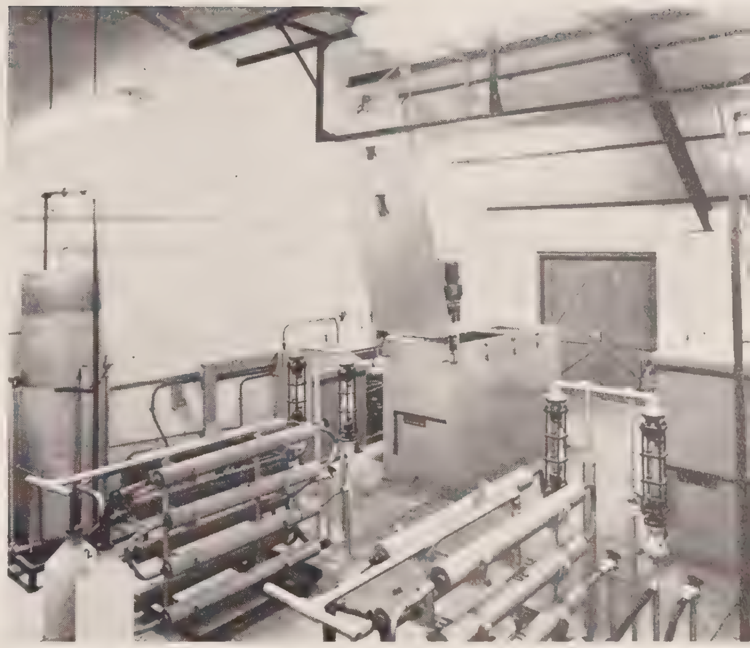
amounts being dissipated as heat. If the amount of metabolisable energy lost as heat is large, the amount of net (useful) energy will be small—i.e., the net availability of the metabolisable energy will be low.

Ruminant animals are much more wasteful of the energy they derive from carbohydrates than are simple-stomached animals, and data available makes it clear that the difference is far greater than that which can be attributed to the energy cost of rumination or the heat lost as a result of bacterial fermentation in the rumen.

In non-ruminants the carbohydrates of food are broken down by digestive enzymes to hexoses and absorbed in that form. In ruminants, however, the major end-products of carbohydrate digestion are the steam-volatile fatty acids (acetic, propionic and butyric)—the result of bacterial fermentation in the rumen. From analyses of rumen liquor in the literature it would appear that roughages are associated with the formation of mixtures of acids containing high proportions of acetic acid and low proportions of propionic acid, whereas with concentrates the proportion of acetic is much reduced and the proportion of propionic acid increased.

In order to determine whether the lower efficiency of utilisation of the metabolisable energy from carbohydrates by ruminants is associated with the fact that these animals absorb much of the energy in the form of steam-volatile fatty acids, experiments have been made in which mixtures of steam volatile fatty acids have been infused into the rumens of sheep maintained in respiration chambers. From these experiments, it appears that a major cause of the lower efficiency of utilisation of carbohydrate foods by ruminants compared with simple-stomached animals is that in the former most of the energy is absorbed as steam-volatile fatty acids and not as hexose. It is also clear that in order to predict the value of a food as an energy source for ruminants, it is necessary to know not only how much of it is digested but also the chemical nature of the end-products of digestion which are absorbed. In the experiments which led to these conclusions the major productive process within the body was fat deposition. For growth and for the production of wool or of milk the efficiencies of utilisation of the end-products of carbohydrate digestion may be different from those for fattening and need to be evaluated. In this connection, work is in progress on the efficiency of utilisation of the steam-volatile fatty acids for milk synthesis. It is interesting to note that with fed and lactating goats the infusion into the rumen of 700 kcal/day propionic acid lowered the butter fat percentage from 4.1 to 2.4 within three days and an infusion of acetic acid raised it to 5.4.

It will be appreciated that energy metabolism studies such as the above should prove of value not only in the prediction of food values but also in indicating the extent to which man may yet learn to control livestock production through knowledge and control of the intermediary processes in the conversion of vegetable to livestock products.



One of the three respiration chamber rooms in the sheep metabolism house at the Hannah Institute. Each room has two respiration chambers for sheep or goats.

The cattle respiration chamber at the Hannah Institute with the door open. The control plant is on the floor below.

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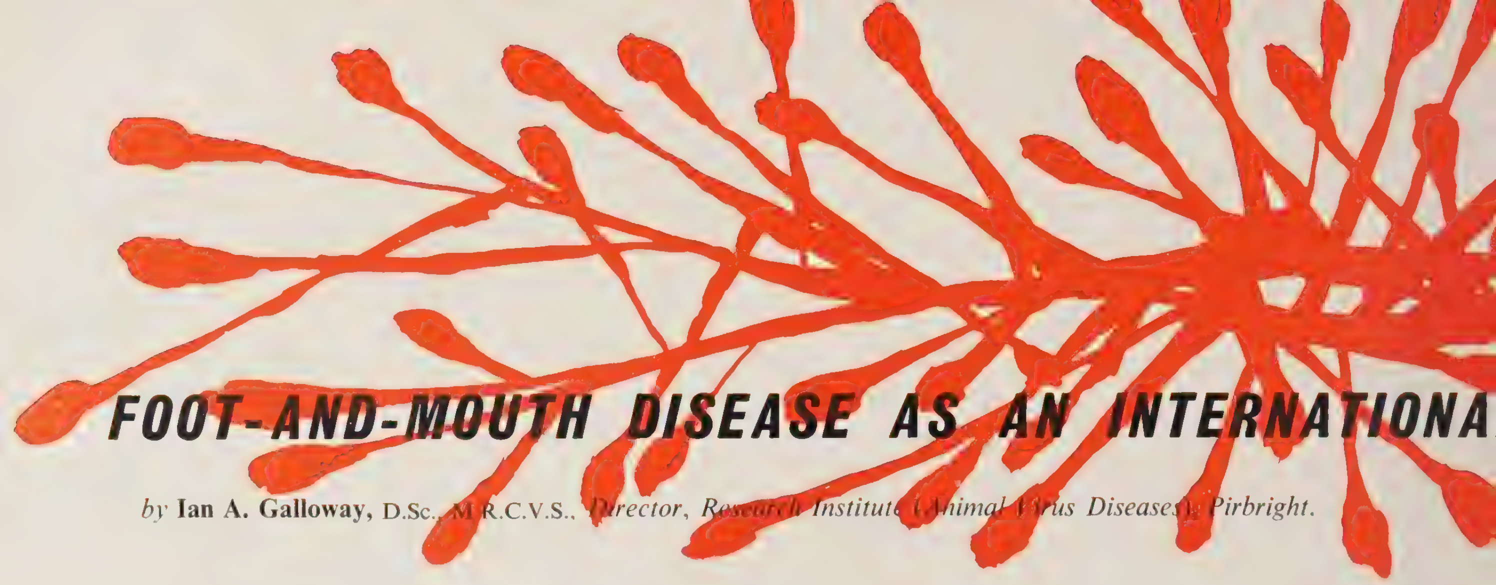


FOOT-AND-MOUTH DISEASE AS AN INTERNATIONA

by **Ian A. Galloway,** D.Sc., M.R.C.V.S., *Director, Research Institute (Animal Virus Diseases), Pirbright.*

The control of diseases of livestock is recognised as of great importance for improving animal production, food supplies, the promotion of international trade in livestock and products of animal origin, and the general economy of countries throughout the world.

Although there are other diseases with more dramatic acute manifestations and high mortality, such as rinderpest (cattle plague), foot-and-mouth disease (FMD) is universally accepted to be the most troublesome and difficult to control. Until quite recently, in many countries in Asia and Africa, very little was done to attempt to control FMD because the main concern of the veterinary authorities was the control of the killing diseases. As the result of better control of rinderpest, increasing attention has been given internationally since about 1954 to FMD, but an overall programme of effective control is still quite far off. It has come to be realised that the disease has to be tackled as a world problem if real progress is going to be finally achieved.

Its persistence, and the periodic appearance of FMD in the epidemic form in one continent or country constitutes a serious and continual threat, not only to immediate neighbours, but to other countries throughout the world. Some countries are extremely fortunate in enjoying exceptional freedom—for instance, Australia, New Zealand, Canada, the United States and Japan. This comparative freedom (the USA had its last outbreak in 1929; Canada has had only one outbreak, in 1952; and Australia has not been invaded since 1872) is due not to any peculiar inherent resistance of their livestock to infection with the disease, but to their favourable geographical position, and to the stringency of their disease security import regulations for animals, animal products and animal feeding stuffs. These countries have to be constantly on the *qui vive* as they are fully aware of the increased risks of introduction of the disease due to the more rapid and frequent communications by sea and air.

FMD is endemic over most of the rest of the world: South America, Asia, most African territories, and most countries on the continent of Europe, with the exception of certain countries such as Norway where the disease is very rare. In Great Britain, which has the advantage of no land frontiers, the disease is not endemic, but there are sporadic outbreaks, due to imported infection, at irregular intervals with varying degrees of severity of spread.

Cattle, sheep, pigs and goats are all susceptible to FMD. So are many wild animals, e.g., buffalo, deer, impala, kudu, gnu, eland, boars, tapirs, wild pig and other cloven-footed animals; this complicates control procedures, especially in African countries. In addition, hedgehogs and porcupines have been found infected with the disease under natural conditions, as also have rats. Guinea-pigs, rabbits, hamsters and mice can all be infected by inoculation, and these small laboratory animals can be used for many large-scale tests and experiments to supplement or prepare for tests on, for example, cattle and pigs.

The disease is very contagious and infectious, and in some outbreaks spreads very rapidly. Although it cannot be regarded as a killing disease, in adult animals the mortality rate being only 1-3 per cent., the death rate in lambs, calves and piglets can be very high. However, the seriousness of the disease lies in its dire effects on the animal economy. Dairy cows are particularly severely affected and in addition to loss of condition and reduction of milk yield, abortion, sterility, loss of hooves, inflammation of the udder sometimes leading to permanent impairment, and chronic joint affections, can result from secondary infection. Complete recovery in such cases is rare, or takes a long time, and in many cases it is not an economic proposition to keep the animals alive. There are losses of meat, milk, butter and cheese.

The general characteristic symptoms are increased salivation and lameness due to the painful blisters which develop in the mouth and on the feet. Blisters also occur on the teats and udders of cows, and calves and other unweaned animals may die from a paralysing infection of the heart and muscles, often without feet or mouth being affected. The severe lameness experienced is a great handicap in countries where trekking of cattle takes place, and it is the most noticeable feature in sheep and pigs. The secretions and excretions of diseased animals are infective even before they show the characteristic symptoms.

The cause of FMD is a very small virus, similar in size to that of poliomyelitis, which is highly resistant to many physical conditions outside the body and to many of the common disinfectants which destroy bacteria. It can thus

be carried on such diverse materials as shoes and boots, clothes, sacks, harness and ropes, hay, straw and bran, the hides and skins of animals and the feathers of birds, for lengthy periods. Ingested virus can pass through a bird's intestine and remain infective. The virus will survive the treatment and storage conditions applying in the meat trade and on meat wrappings, for considerable periods. The feeding of infective offal to pigs under experimental conditions has resulted in the appearance of the disease in these animals.

Multiplicity of Virus Types

Although foot-and-mouth disease is considered as a single disease because the clinical signs and the general characteristics of the virus are the same whatever type the animals may be infected with, from the point of view of control, it can reasonably be stated that there are, in reality, seven different diseases. It has been demonstrated that there are seven types of the virus and recovery from or vaccination of animals against any one of these leaves the animal susceptible to any of the other six. Thus any control policy which involves vaccination must generally provide for immunisation against more than one virus type. The selection of the types of the virus which the vaccine should cover for a particular country or area must be based on the information provided by epidemiological surveys carried out by the World Reference Laboratory at this Institute on the distribution of types in the different areas of the world.

In addition to the various types of the virus, it has been demonstrated that within each type group there are a number of sub-types which can be differentiated by serological tests. These are also important in relation to the problem of providing the most effective vaccines in particular circumstances.

So far, we have considered the nature of the disease and some of the main factors involved in trying to devise a programme for effective control from an international point of view. The main object is, in the first place, to diminish the incidence of the disease in the areas where it is endemic, and finally to achieve eradication.

Quite apart from the effects of the disease on animals, it has to be borne in mind that it leads to great interference with import and export trade in susceptible livestock and in a wide range of animal products and feeding stuffs, especially if these are in sacks. Because of the risks of introducing the disease, restrictive disease control security measures have to be applied. This problem has to be considered, on the one hand, from the point of view of countries into which the virus has not been introduced, and on the other hand in relation to countries where the disease is endemic, but into which virus types or sub-types foreign to the area might be introduced.

Thus no country can look upon foot-and-mouth disease with complacency, and in fact all countries, whether they are at present free from infection or not, are equally interested in the results of research on the disease and in the problem of control being considered on an international basis.

Methods of Control

The importance of making a contribution to the hard-pressed cause of clear thinking has been realised, but it is not easy in the heavily charged atmosphere which prevails during an epidemic of the disease. It is not possible at all without adequate knowledge, but nevertheless at such times there are voluble advocates for the adoption of different policies without the requisite information and without consideration of all the facts in relation to the circumstances.

The approach to the problem must be based on the consideration of two aspects:—

1. The adoption of measures to avoid risks of introducing FMD into countries which are free, or of introducing types (or sub-types) of the FMD virus which are foreign (exotic) to a country or areas where the disease is already endemic, and thus adding to the already heavy burden of control by vaccination against types of FMD virus already present; and
2. When the disease invades a country or is already endemic there, the adoption of measures to limit its spread and eradicate it.

Control of the disease in general is based on quarantine and sanitary measures, rigorous disinfection and either (*a*) a slaughter policy or (*b*) vaccination supplemented or not by a limited slaughter policy.

With regard to the measures to avoid risks of introduction of the disease, these are obviously easier for countries with no land frontiers, such as Australia and New Zealand, or with limited land frontiers such as the USA and Canada.

The main, but not the only, risks are attached to the importation of susceptible animals, meat and meat products, and restrictive measures must be applied to avoid the other risks as well. With regard to animals there may be absolute prohibition of importation or, in exceptional circumstances, very limited importation under appropriate conditions during transit, and quarantine measures in the exporting and importing countries.

The dangers of importing unprocessed or unsuitably processed (e.g. pasteurised hams) meat and offal have been clearly demonstrated by experimental evidence. It is feasible for some countries (e.g., Australia, New Zealand and the USA) to ban completely the importation of these animal

Very thin sections of virus-infected tissues are prepared on this ultramicrotome; when viewed on the electron microscope they provide information on the mechanism of virus multiplication in the cell.

products from countries in which the disease is endemic. Other measures are taken also when appropriate; for example, in the USA garbage is destroyed from ships which may have picked up stores in countries where foot-and-mouth disease exists.

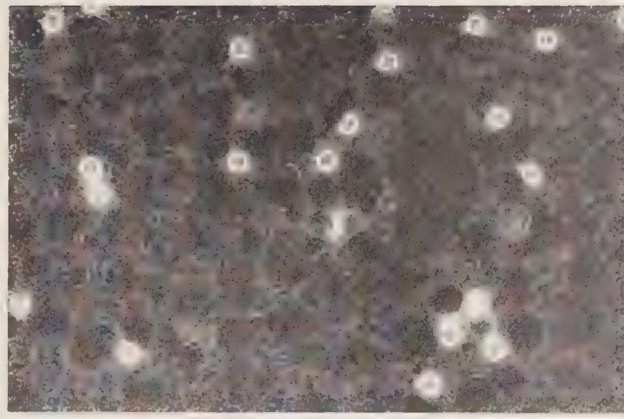
It is worthy of note that international organisations—FAO, with the European Commission for the Control of Foot-and-Mouth Disease and the International Office of Epizootics (OIE), and also the Inter-African Bureau of Animal Health—have been paying special attention to the problem of trade in meat in relation to the risks of dissemination of foot-and-mouth disease and other virus diseases. The importance of this problem is fully realised, especially as it is not feasible for all countries to put an embargo on the importation of all meat and meat products from endemic areas.

In this connection, Great Britain, which does import meat from countries in South America where the disease is endemic, keeps a watchful eye on the meat industry there and applies appropriate specific restrictions to diminish the attendant risks. These include the Disease of Animals (Waste Foods) Order, which prohibits the feeding to animals of garbage which may contain meat scraps, unless boiled for one hour; and, more recently, the banning of importation of pig meat from South America. In some countries which import meat and meat products, insufficient or no attention is paid to the risks of introduction of the disease from this source.

The appropriate policy of control of foot-and-mouth disease has to be decided on the circumstances obtaining in the particular country, and on what is possible and practicable in these circumstances and in the light of our present state of knowledge. Is the disease already endemic or is it introduced at irregular intervals? It is not endemic in Great Britain, where introduction is attributed to importation of meat from countries in South America and to proximity to the continent of Europe. Every time there is an increased incidence of foot-and-mouth disease on the continent, there is an increase in the number of outbreaks in Great Britain; significance is attached to the extensive migration of birds, which can carry the disease mechanically, but there are other possibilities as well.

A Departmental Committee on FMD set up by the British Minister of Agriculture reported in 1954 that in the current state of knowledge the slaughter policy which was applied in the UK should continue. (This is more correctly a 'stamping out' policy involving immediate reporting of suspicion of infection; effective control measures to stop movement of animals; the tracing of 'in contact' animals; disinfection of infected premises, of vehicles which may have carried infected animals, and of milk cans, etc.; and the slaughter of infected and 'in contact' animals.) This policy gives more efficient control than would vaccination and the total cost involved is much smaller. The subject was discussed in an article entitled Sticking to Slaughter in *The Economist* of 11th February, 1961.

In countries where the disease is endemic vaccination has to be applied alone or combined with limited slaughter of infected animals; in these countries a complete 'stamping out' policy would not be feasible. However, it must be realised that vaccination alone, without supplementary control measures including physical control of livestock



Virus of foot-and-mouth disease: large infective particle stained with phosphotungstic acid. (Magnification x 133,000.)

Attendants in one of the large animal units spray each other with disinfectant; one of the many strict precautions taken to prevent any possibility of spread of the disease from the Institute.

(*cordon sanitaire*), disinfection and (e.g., in African countries) limitation of movements of wild game by fencing, etc., is not likely to be effective.

Research

The Research Institute at Pirbright is the World Reference Laboratory for FMD, a responsibility for which it is well suited in view of its 10 years' experience (1948-58) in examining 2,200 virus samples from all over the world and because it has the necessary facilities for the examination of suspect material.

Up to 1948, three types of FMD virus, *O*, *A* and *C*, had for many years been recognised in outbreaks in Europe and South America. During 1948-58 these three types were confirmed in many parts of Africa, the Middle East, the Far East, and certain Central and South American countries, and in Canada (the only outbreak ever to have occurred there). There were also confirmed the existence of three additional types—*S.A.T.1.*, *S.A.T.2* and *S.A.T.3*—in Africa and a seventh type—*Asia 1*—in a number of Asian countries. So far, the three *S.A.T.* types have not been found in Europe, South America or Asia; the *Asia 1* type has not been found in Europe, Africa or South America, and the *O*, *A* and *C* types have not been found in South Africa, the Rhodesias, Mozambique and Bechuanaland.

The fact that as many as four types of virus have been found in some countries, and three in many, indicates the magnitude of the problem of arranging vaccination programmes for those countries where the disease is endemic.

Prompt reporting of suspicion of FMD is of first importance in any system of control and, for quick action, rapid confirmation of diagnosis and typing is just as important. Modern laboratory techniques which have been developed enable results to be obtained much more quickly than in the past.

Work is being done in various countries on the use of both inactivated vaccines and living attenuated strain vaccines for control of the disease. The best results with the Pirbright live attenuated strain vaccines have given 90 per cent. protection and a larger dose has given 100 per cent. protection in tests on British cattle at Pirbright—but not all attenuated strain vaccines have given equally good results, and research is continuing. Field trials with the Pirbright live vaccines have been carried out in Africa and Asia with promising results.

Many scientific disciplines have to be applied to the study of a virus disease such as FMD, with a view to a full understanding of the disease and to the possibility of developing an entirely new approach to the problem. Biophysics, biochemistry, pathology, cytology and genetics are all included in current research. Most of the measures for the control of FMD which have been developed in the field have been founded on work done in the research institutes, and it is essential that research on the disease should go on, and be extended.

As outbreaks of foot-and-mouth disease continue to occur in different parts of the world it is clear that there is also still much work to be done in establishing more effective international cooperation between governments and veterinary authorities; in strengthening services; and in increasing help for the control of the disease in the less developed areas.

Achievements

by **J. F. Filmer,** D.V.Sc.

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New Zealand Department of Agriculture.

Symptoms of facial eczema seen in this sheep are swollen and droopy ears, secondary lesions on eyelids due to irritation, and oedema of the muzzle.

Facial eczema is a serious disease which affects sheep and cattle in many districts of the North Island and in the most Northern districts of the South Island of New Zealand. It was first reported in 1898 but may well have occurred earlier (1). Recently it has also been reported in the Gippsland district of Victoria, Australia (2). In this article Dr. Filmer gives a step-by-step account of the work which, over a period of years, led to the discovery of the fungus which is now believed to cause facial eczema, and which more recently has continued as an investigation of the organism itself, the conditions under which outbreaks are likely to occur, and the best means of controlling the disease.

Essentially facial eczema is a disease of the liver, sometimes associated with lesions of bare, unpigmented or lightly pigmented areas of skin.

It affects animals grazing pastures consisting largely of grasses and clovers and occurs only in late summer and autumn, always appearing to be precipitated by warm rains, especially if these have been preceded by a hot dry period.

The skin lesions have been shown to be due to photosensitisation by phylloerythrin, a porphyrin derived from chlorophyll in the digestive tract. In normal animals phylloerythrin is excreted in the bile, but in facial eczema and some other similar diseases the damaged liver is unable to excrete all of the phylloerythrin and it reaches a dangerous concentration in the peripheral circulation, and photosensitisation occurs (3).

In the widespread, disastrous outbreaks which occurred in 1938, it was observed that facial eczema was very pre-

# of Research in Facial Eczema

valent in sheep and cattle grazing pasture dominant in perennial ryegrass. Before the autumn rains these pastures, which were usually heavily stocked, were grazed bare and there was a heavy accumulation of faeces. The warm rains suddenly made available this accumulation of plant food and also provided the moisture and warmth required for maximum growth. Perennial ryegrass responds extremely rapidly to such conditions and in many of the worst affected areas the pasture appeared to consist almost entirely of young rapidly growing ryegrass.

All attempts to transmit the disease had failed and examination of affected pastures did not disclose any poisonous weed or fungus. In these circumstances it was postulated that facial eczema might be due to an aberrant plant metabolite produced in perennial ryegrass or some other pasture species under the special environmental conditions associated with outbreaks of the disease.

Attempts to substantiate this hypothesis were handicapped because pasture often remains toxic for only short periods; on the other hand, liver damage continues to develop after ingestion of the liver damaging factor has ceased. Therefore pasture collected after symptoms have appeared in grazing sheep is frequently not toxic. Apparent confirmation of the hypothesis was, however, obtained in 1941: pasture was mowed daily from an experimental paddock and fed to penned animals; a serious outbreak of facial eczema occurred in the lambs grazing in the experimental paddock and characteristic liver damage occurred in the pen-fed lambs.

From then on efforts were concentrated on the chemical identification of the liver damaging factor. To make this possible it was necessary to find some method of preserving the pasture which would not destroy the liver damaging factor. Boiling and canning, freezing and preserving in alcohol, were tried and discarded either because the liver damaging factor was destroyed, or because the process proved too difficult or costly to apply to the large quantities of pasture involved. In 1943 it was shown that pasture dried by hot air at a temperature between 100° and 110°C retained at least some of its toxicity, and subsequently heat-dried pasture, collected from paddocks in which facial eczema occurred in grazing lambs, was used in the search for the liver damaging factor (4).

Practical Difficulties

The task of the chemists was hampered by many difficulties. Facial eczema occurs only sporadically and sometimes no toxic grass could be collected for several years. In some cases drying appeared to destroy toxicity and toxicity declined at varying rates in samples of stored heat-dried pasture. The only way in which the presence of the liver damaging factor could be detected in any chemical fraction was to feed it to lambs, and the equivalent of 20-50 lb. of dried grass had to be fed to a single lamb over a period of several weeks to produce recognisable liver damage. This made it necessary for chemists to work with quantities so large as to be unmanageable in any ordinary laboratory. Naturally progress was very slow.

In 1943 when toxic dried grass was fed to mature guinea pigs their response was very variable and they were therefore discarded as test animals, but later it was shown that young guinea pigs are fairly sensitive to the liver damaging factor and they have been used as routine test animals, approximately 2 lb. of dried pasture being fed over a period of four weeks to each guinea pig. This reduced the quantity necessary for each chemical procedure to more manageable proportions and progress accelerated (5, 6).

In 1952 it was shown that continuous extraction of toxic dried pasture with ether removed most of the liver damaging factor and methods were gradually evolved for producing extracts with increasing concentrations. In 1955 an extract was produced which contained only 1/2,000 of the original dry matter without material loss of toxicity. By 1958 it was possible to produce regularly a concentrate

containing only 1/70,000 of the dried matter in the pasture and about half of the liver damaging factor originally present. Occasionally concentrations of 200,000 or 400,000 were achieved, and on one occasion a toxic fraction was produced containing only 1/2,000,000 of the original dried matter; but even at these high concentrations there was no clue to the identity of the liver damaging factor, as fractions of similar weight and physical properties prepared from non-toxic pasture could be differentiated from the toxic fractions only by feeding to test animals (7).

During the extraction of toxic pasture, a white deposit frequently occurred on the wall of a beaker following evaporation of an extract (8); the structure of this substance has been partially clarified by the identification in hydrolysates of a hydroxyacyldipeptide (9). The so-called beaker test has been based on the fact that this substance often occurs in association with the liver damaging factor; it has the advantages that it requires only 50 gm. of dried pasture and can be completed in a few hours, and has proved valuable for spotting toxic samples of pasture. However, as the beaker test substance is not the liver damaging factor, the test cannot be relied upon absolutely (10, 11, 12).

Discovery of Fungus

In 1958 there occurred a dramatic discovery which altered the whole course of facial eczema research. Fungal spores were collected from the blades of a mower being used to collect toxic grass; they were submitted to the beaker test and gave a strong positive reaction. The spores were cultured in the laboratory and cultures were subjected to the beaker test and fed to guinea pigs with negative results. Later, however, a high sporing strain was isolated from the original culture and cultures of this strain gave positive beaker tests. Typical facial eczema was produced in both guinea pigs and lambs by feeding cultures of the fungus, which is now identified as *Pithomyces chartarum* (13, 14, 15).

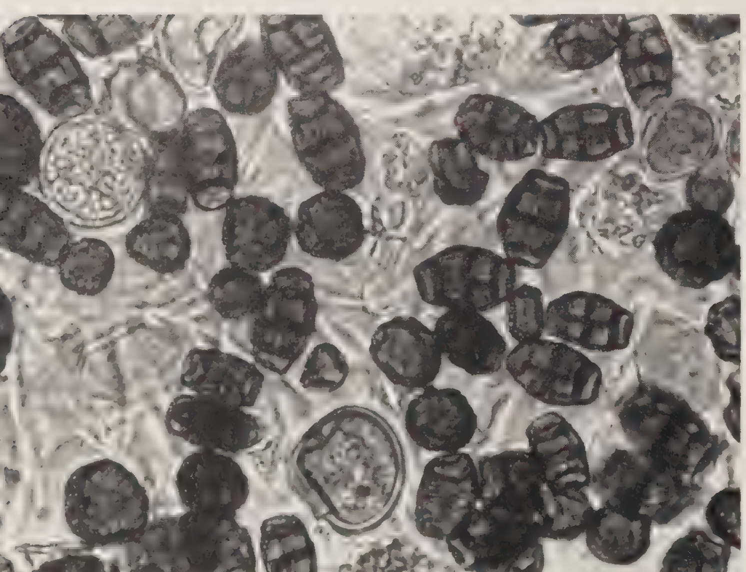
It was natural that attention should now be diverted from pasture to the fungus. About a year after its discovery, the liver damaging factor was isolated from fungal cultures in crystalline form in combination with CCl_4, and in this form it has an empirical formula $C_{19}H_{21}O_6N_3S_2Cl$, CCl_4. The toxic substance has been named Sporidesmin, from *Sporidesmium*, the genus in which the fungus was previously placed (16).

A chemical test for Sporidesmin has been devised based on the removal of free iodine from a sodium azide-iodine solution. The test appears to estimate Sporidesmin with reasonable accuracy in fungal extracts, but it cannot yet be applied to pastures (17).

Fungal cultures, culture extracts and Sporidesmin are being used to study the biological reactions of this substance. It has already been shown that HeLa[1] cells are destroyed by very dilute solutions of Sporidesmin and this reaction can be used for the detection of minute quantities (18). The rabbit eye is extremely sensitive to Sporidesmin and its presence in extracts can be demonstrated by applying them to the surface of the cornea (19).

In a very neat series of experiments with rabbits to which Sporidesmin had been administered, bile was taken from the bile duct at intervals after administration. The serial samples were placed in the small intestine of other rabbits, and in some of these typical liver damage was produced.

[1]HeLa: a standard form of tumour cells used for work in tissue culture.



Spores of Pythomyces chartarum *caught on a mobile spore trap.*

The animal on the right shows photophobia, a symptom of facial eczema.

Casts of bile ducts and blood vessels: normal on left; affected by facial eczema on right.

It was thus demonstrated that at least some Sporidesmin is excreted in the bile and can be reabsorbed in sufficient quantity to produce detectable liver damage (20, 21, 22).

The antigenicity of the fungus and of Sporidesmin is being studied with a view to determining if control by vaccination is feasible.

The cultural requirements and the ecology of the fungus are being studied both in the laboratory and in the field. In the laboratory it has been shown that the fungus is fairly tolerant of variation in temperature, but high temperatures and high relative humidity favour germination, growth and sporulation. Under optimum conditions colonies sporulate three days after germination (23); spores are not discharged forcibly but the mildest desiccation brings about shedding by rupture of the conidiophore wall. In the field, spores are easily disturbed by movement and are transported by wind.

Pasture litter has been collected from many localities and the strains of the fungus isolated from these vary considerably in both morphology and toxicity under laboratory conditions (24). There is, however, no positive evidence of major variations in pathogenicity of different strains in the field.

In culture, spores, mycelia and culture fluid, all contain Sporidesmin.

Ecology of *P. chartarum*

Pythomyces chartarum is a saprophyte which grows on relatively fresh debris of a great variety of herbaceous plants. It will grow on damaged grass leaves or on the surface of living leaves in the presence of leaf exudates. There is a wide variation in the growth on material from different plant species: growth is very vigorous on litter from Yorkshire fog and relatively so on ryegrass litter, but sweet vernal litter inhibits growth, probably because of its coumarin content (25). In a rather limited number of observations, no spores have been found on the litter from turnips. While growth occurs rapidly on damaged ryegrass leaves, growth does not occur on the damaged leaves of red and white clover.

Anything which increases the amount of plant litter, or damages growing plants, increases fungal growth. This may be done by mowing and leaving the clippings in the paddock, or by severe harrowing; both procedures have provoked liver damage in grazing lambs when it did not occur in lambs grazing untreated adjoining paddocks. As it is unlikely that lambs eat the litter, it is probable that spores adhering to pasture leaves are the cause of the liver damage. This suggestion receives some support from the good correlation which exists between spore counts and liver damage when other factors, such as pasture species, pasture growth, temperature and humidity, are relatively constant (26, 27).

To assist in making spore counts, a volumetric spore trap has been devised which sucks up the spores as it is pushed over pasture, and deposits them on a microscope slide (28).

The warm humid conditions which follow autumn rains are favourable for growth and sporulation. When these rains follow prolonged dry periods, pastures in heavily stocked paddocks are usually grazed bare and very little plant litter is present, yet such conditions have produced some of the most severe outbreaks of facial eczema. It is possible that the stimulation by leaf exudates is important

at such times as they are relatively abundant in rapidly growing young ryegrass (29).

The effect of variation in height of pastures produced by different intensities of stocking during summer and autumn has been studied, but so far there have been no consistently significant findings. It is obvious that the ecology of the fungus in pasture swards must be intensively studied.

Control of the Disease

When it was shown in 1941 that facial eczema was caused by the ingestion of toxic grass, it was concluded that it could be prevented by reducing the ingestion of such grass to a minimum. The discovery of the fungus has not invalidated this conclusion though it now appears likely that the liver damaging factor is in spores attached to the pasture plants and not in the plants. The control measures recommended have been the feeding of safe crops such as rape, kale, turnips or pure white clover, or shutting up at the rate of 200 sheep or more per acre and feeding on hay during dangerous periods. These measures have been completely successful where they have been rigorously practised (30), but they have not proved popular.

It is not easy to define the dangerous periods. If precautions are taken following all warm autumn rains until the pasture visibly hardens, facial eczema can be prevented. However, it is known that the disease does not follow all warm autumn rains and there is still no certain way of differentiating between the rains which induce facial eczema and those which do not. In many districts cropping does not fit readily into current farm practice. Shutting up and feeding of hay cannot be practised with lambs unless the hay is of very good quality and the lambs have been taught to eat it, otherwise disastrous loss of condition occurs. Occasionally salmonellosis occurs in ewes crowded into small areas.

The discovery of the fungus suggested the possibility of other control measures, based on rendering the sheep resistant to Sporidesmin or controlling the growth and/or sporulation of the fungus. Vaccination would be an eminently practical procedure if a sufficiently potent vaccine could be prepared; although this is being attempted, it is too early to do more than hope for success.

Control by fungicides has been tired: fungicides shown to be toxic to the fungus in the laboratory have been sprayed on to pasture at weekly intervals without reducing the fungal population to a safe level. It is possible that a more potent fungicide may be discovered but effective control by fungicides seems rather unlikely, as the timing problem would still remain, repeated applications would be costly, and many fungicides are quite toxic to sheep.

There remains the possibility of reducing the fungal population to a safe level by some method of pasture management. It is known that in most facial eczema outbreaks many sheep suffer some degree of liver damage without showing serious symptoms: in the mildest cases there is complete resolution; in others quite extensive permanent liver damage occurs, but new liver tissue generates sufficiently rapidly to prevent serious loss of liver function. Such sheep either show no symptoms or recover rapidly after a period in which they may show some skin lesions and jaundice or only loss of condition. They then remain healthy until exposed to some special stress such as parturition.

Many farmers have learnt that some paddocks are safer than others and except when the risk is considered very great they merely turn their sheep into these relatively safe paddocks. Under such conditions some liver damage occurs, but the measures have generally proved fairly satisfactory, though there have on occasion been disastrous losses.

It is hoped that a further study of the ecology of the fungus in the pasture sward, and a more exact knowledge of the number of spores sheep can tolerate, will enable control measures to be evolved which will prove more satisfactory than those now recommended.

Acknowledgements

This article is essentially a review of the work of a number of the author's colleagues; in adopting a narrative style it has not been possible to acknowledge their individual contributions in the text nor to refer to the different research organisations which participated in the investigations. References are given to published work and some personal communications are also gratefully acknowledged.

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Two Grazing Disorders

1. Hypomagnesaemia

What causes it?

When cattle are put out to pasture in the spring two problems can arise as a result of the change from winter feed to young grass: one of these is bloat, the other takes the form of a disorder associated with a low level of magnesium in the blood, and known as hypomagnesaemia. This disorder is also commonly called 'grass tetany' or 'lactation tetany', names which are somewhat misleading in view of the fact that the condition can arise in animals kept on winter rations in stalls or yards, and in non-lactating animals.

Hypomagnesaemia occurs in most temperate countries which have a highly developed agriculture. Although it has not been reported in the tropics there may still be an incipient threat in these areas but, because of the lower intensity of agricultural production, this has not yet been realised. Despite the fact that it is now 30 years since it was first associated with a low blood magnesium level by the two Dutch workers, Sjollema and Seekles, the primary cause of hypomagnesaemia is still unknown.

Although hypomagnesaemia most commonly occurs with a sudden change from winter feed to young grass, it can still occur even when the change is made gradually. This is especially so among dairy cows. At first they lose their appetite and milk yield decreases; this usually happens between the first and third week after being put out to pasture. The symptoms of hypomagnesaemia show a variety of forms, however, depending on the intensity of the attack: initially, they often include nervousness, restlessness, lack of appetite, twitching of the muscles (especially of the face and eyes), grinding of the teeth, anxious or wild expressions, tetanic contraction of the muscles of the tail, and a staggering gait. In severe cases, paralysis and violent convulsions develop soon after the onset of symptoms and, if treatment is not given, exhaustion and death supervene. Sometimes progress of the disorder is so rapid that the animal dies before it can be treated. Chronic cases occasionally occur in which lactating cows show a gradual loss of condition, though the appetite and milk production may remain normal. This state may remain unchanged for weeks and then be followed by the more typical symptoms described already.

Generally, two distinct forms of hypomagnesaemia can be recognised: an acute form, in which the fall of blood magnesium is sudden; and a slowly developing form, in which the blood magnesium falls slowly throughout the autumn and winter. The latter type is more common in out-wintered stock which may show no clinical symptoms, even though blood magnesium is low; in some animals an acute attack may be precipitated by a variety of causes, such as shock, the strain of parturition, rough handling and dog worrying. In milking cows, the disorder is commonest during spring, but it also occurs during autumn on a fresh growth of grass. In beef cattle, out-wintered dry cows and young stock, it is commonest during the winter months when there is little or no grass growth. The symptoms may occur at any time in cattle of either sex of all ages and breeds. Sheep are also affected, but they do not exhibit such marked external symptoms as cattle.

It is known that hypomagnesaemia may appear and disappear within a few days without any change in diet. A fall in blood magnesium can occur within a matter of two days when cows are transferred from stall to spring pastures; but blood magnesium values usually return to normal in a few days when animals are removed from a hypomagnesaemic prone pasture, housed, and fed concentrates with a magnesium content similar to the pasture which has caused a fall in blood magnesium.

Norwegian workers have produced evidence that rations which provide a low intake of magnesium can cause a fall in blood magnesium levels in adult cattle. Work in New Zealand has shown that a deficiency in food energy intake can induce hypomagnesaemia in lactating cows, and that underfeeding can produce clinical symptoms. However, underfeeding naturally means that less magnesium can be taken in by the animal.

Chemical Composition of Herbage

The general opinion of most investigators is that whatever the primary physiological causes, the chemical composition

of the herbage is important, and is, in fact, one of the chief factors involved. It is known from work done at Durham University that there is a marked difference between the magnesium content of grasses and broad-leaved plants.

Average values for species, on a dry-matter basis, are:—

Grasses	0.24%
Legumes	0.69%
Herbs	0.75%

The possibility of inorganic fertilisers being the cause of the trouble has received some attention. Experience in Holland, where farms return urine to the field from the farm buildings, has drawn attention to a relationship between potash level and incidence of the disturbance. On one farm with a high incidence of hypomagnesaemic troubles, it was found that the urine had a high potash status: when the farmer was persuaded to sell his liquid manure and turn all the herbage near the buildings into silage, the trouble was eliminated. It would seem that here hypomagnesaemia was possibly due to the herbage taking up the mono-valent potassium ion in preference to the di-valent magnesium ion, resulting in a mineral imbalance.

Some animals are more susceptible than others, and it is therefore necessary to consider all aspects of the animal, the herbage to be consumed and the soil on which the herbage is produced, in any studies on the cause of hypomagnesaemia.

Our present state of knowledge suggests that hypomagnesaemia cannot be correlated with soil type or with magnesium content of soil or herbage; nevertheless, the condition appears to be more prevalent on some farms than on others. Increased incidence is often associated with improvement of grassland and of intensive systems of farming where heavy applications of inorganic fertilisers are used. Pastures on which this disorder occurs often have a low magnesium content, though this is not always the case, and it sometimes occurs when the magnesium content is normal, or even high. Whatever the cause, however, intravenous injections of magnesium salt, if given in time, nearly always effect a spectacular cure, comparable with that of calcium salts in the case of milk fever.

Preventive measures which can be taken include the feeding of fortified magnesium concentrates for the critical periods, such as spring turn-out (2 oz. magnesium oxide per day for adult cattle is the recommended dose). In addition, the change from hand feeding to spring pasture should be undertaken gradually. Other measures which can be helpful include applying a magnesium salt to pastures, and, in view of the apparent correlation between hypomagnesaemia and potash levels in the herbage, ensuring that these levels do not become excessive in swards of pure grass (as opposed to grass/legume mixtures).

What is clear about hypomagnesaemia is that no one measure will result in its control. The many variable differences between individual animals and their management, soils, herbage composition and fertiliser treatments, all complicate the picture.

F. B. HEAD.

Typical hypomagnesaemic tetany in a young calf.

2. *Bloat*

Control with a mineral oil

Bloat in dairy cattle is commonly associated with the grazing of clover-dominant pastures, accompanied by acute discomfort and even death of animals. It is a metabolic disorder in which gases released by digestion cause foaming of the contents of the rumen; for this reason anti-foaming agents have been employed to relieve the condition. In the past, kerosene and certain vegetable oils have both been used but they are no longer considered suitable because of the undesirable side effects they produce. Recent work in New Zealand has shown that certain mineral oils can be used safely and successfully as anti-foaming agents to control bloat, and one such oil, Ondina 33[1], a highly refined lubricating oil, has been extensively used for this purpose by farmers in New Zealand.

It is difficult to assess the economic importance of bloat in individual countries because this depends to a great extent on the weather conditions from year to year. It is reputed to cost the US cattle industry 40 million dollars annually, and to account for between 10,000 and 20,000 deaths of dairy cows each year in New Zealand. The total economic loss cannot of course be measured in terms of dead animals alone, as lowered milk production and the decreased feed intake of beef cattle, even under mild bloating conditions, is probably of greater importance than the actual death toll.

Many hypotheses have been put forward to explain why bloating occurs: these include lack of fibre in diet; over-eating of succulent feed; the presence of specific muscle poisons in the herbage; and too rapid gas production. But none of these theories alone can explain why some animals in a herd bloat, while others on the same pasture do not.

After a pasture has been intensively grazed and rested, the clover recovers more quickly than the grasses and tends to dominate the sward, rising perhaps to a proportion of 85 per cent. Exactly how low the percentage of clover has to be to provide a safe pasture will depend largely on the selective grazing habits of the animals, but less than 50 per cent. clover is generally considered safe. During the period when dangerous pasture is being allowed to mature, 'safe' feeds (i.e., rough pasture, hay, crops and silage) are often used, but there are obvious limitations to any extensive use of such feeds as they are not always available when an outbreak of bloat occurs. The use of mature grass-dominant pasture will afford protection, although this practice is not consistent with intensive dairying.

The use of mineral oils, such as Ondina 33, offers the best insurance against bloat, and will protect dairy cattle grazing on otherwise bloat-producing pasture. These mineral oils may be administered to cattle, as anti-foaming agents, by one of three methods: oral drenching; treatment of drinking water; or pasture spraying. To be fully effective, a specific concentration of anti-foaming agent must be maintained in the animal's rumen over the whole period during which it is consuming bloat-producing herbage.

As an oral drench, the oil is administered at a dosage of 2-4 fluid ounces per animal, but the dose has to be repeated every 2-4 hours as it passes through the animal fairly rapidly.

The addition of oil to the water supply is probably the most convenient method of administration in the field, but has the disadvantage that drinking habits vary widely from animal to animal, and even in the same animal from day to day. Moreover, when the animals are not drinking at frequent intervals, as in wet weather, the method loses its efficiency. In dry weather, some success has been achieved by maintaining a layer of oil $\frac{1}{4}$ in. to $\frac{1}{2}$ in. thick on all water troughs to which the animals have access. Since the oil gives protection for only 2-4 hours, the animal would have to drink as frequently as this for complete protection. Whilst this method will generally reduce bloating, it does not eliminate the hazard.

Pasture spraying does not suffer from the same limitations, as when the whole area to be grazed is sprayed, the cows have no alternative but to ingest the anti-foaming-agent with the bloat-producing herbage, so maintaining the necessary level in the rumen during the whole period of grazing. The area to be grazed by the cows in 24 hours is sprayed at the rate of not less than 3 fluid ounces of oil per cow per day.

Pasture spraying has been proved the most effective method of administering anti-foaming agents, especially in cases where the outbreak of bloat is severe, or past experience on a particular farm has indicated a prevalence of bloat conditions and outbreaks. The use of mineral oils has reduced the cost of spraying to about $2\frac{1}{2}$d. per cow per day as against a cost of 6d. per cow per day using the more expensive vegetable oils, which have been popular in some countries for many years.

P. V. Fecher.

[1]Ondina 33 is a Shell trade mark.

A NATURALIST IN TURKEY

During 1960, an entomological expedition to Turkey was undertaken by the author, together with Mr. D. H. Harvey of the British Museum of Natural History, in order to collect mainly insects, but also some reptiles and plants, from Asia Minor, which entomologically speaking is little known except to the lepidopterist. Turkish examples of the vast and economically important Order of the Hymenoptera (bees, wasps and various parasitic groups) were scarcely represented in any museum and it was to this Order that special attention was paid. At the same time some Russian insects, unknown to European collections, were secured in eastern Anatolia. The expedition returned with a total of 22,000 specimens.

by **K. M. Guichard**

On 5th May we entered Turkey by road at Edirne near the Greek frontier. This European sector has little to offer the entomologist, except possibly the hills near Bulgaria, and it is intensely cultivated and flat or slightly undulating.

In Istanbul, while waiting to complete formalities for our stay, we collected for three days in the Belgrade Forest which is relatively well known and of limited interest. On 10th May an excursion was made to Sivri Ada, one of the smallest of the islands in the Sea of Marmara. There were few insects on the island but a large population of herring gulls with young. Our chief catch was seven specimens of an elusive lizard now named as *Lacerta sicula hieroglyphica*, a member of a genus that is almost the despair of the systematist. This occasion established a routine for catching lizards which includes the art of anticipating the route they will follow through rocks or from a hiding-place. It requires two persons in a state of nervous tension, one to make a shady refuge with an insect net and the other gently to herd the lizard into it.

Due to our late arrival in Turkey, we first went south before the vegetation dried up. We left Ankara on 24th May, following the route along the east side of the salt lake, Tuz Golu, where small flocks of flamingoes were seen. They probably breed near Tuz Golu and that year two fledglings were caught on the lake and subsequently died in Ankara.

On the Anatolian plateau at 3,000 ft. the wild flowers were still magnificent in a green landscape and the fine tall *Linaria dalmatica* appeared for the first time, bright sulphur-coloured blooms enhanced by the neat blue-green leaves. Another exceptional plant was a golden *Linum* with masses of flowers springing from the bare stony soil. Many of these Anatolian species have not been tried in Britain and they cannot be expected to grow with quite the same profusion as in their native habitat; and indifferent specimens give no idea of their potentialities.

Search for *Schizodactylus*

One purpose of this first journey was to discover *Schizodactylus inexpectatus.* This insect is related to the true crickets as well as to the long-horned grasshoppers and it is remarkable for the curious development of the hind tarsi, the purpose of which is still obscure. Four species of the genus were known from India and nearby countries until the fifth was described from Turkey, a long way from the main distribution area. The description was based on one adult male and one larva and the female was quite unknown. The habitat of the insect was somewhere on the coast at Alata, on the Mediterranean west of Mersin.

Passing through the Taurus Mountains at Pozanti we reached Adana on the coastal plain at the beginning of the summer heat. The revolution which took place on 26th May in no way interfered with our plans. Permission was granted to stay at an agricultural college at Alata and in due course the search for *Schizodactylus* commenced with a survey of the seashore and the sandhills. Various holes were excavated and vegetation turned over or uprooted, but no clue was discovered. The time of year for the maturity of the insect was right and thinking it might be nocturnal we prowled about unsuccessfully in the sandhills after dark, listening for some seductive song that might lead us to the hiding-place.

It appeared a tantalising problem but expanses of sand are best examined in the very early morning when the comings and goings of the previous night lie plainly to be read before the wind rises and obscures them. We were again on the scene at first light and immediately noticed a curious disturbed patch of sand raised slightly above surface level. A stick poked into this 'cast' suddenly went down without resistance into a hidden burrow. Digging began—a careful pursuit along the line of the stick. At the

depth of 2 ft. the stick moved slightly at the prompting of some hidden jaws. Then on its withdrawal out jumped a male *Schizodactylus* into the sunshine and the mystery was solved: it was simply a question of finding other 'casts' and these occurred at about 30-yard intervals along the shore. A good series of this hitherto rare insect was soon obtained, including three specimens of the much rarer female; she will be described by Professor T. Karabag of Ankara University who specialises in the Turkish Orthoptera.

It appears that *Schizodactylus inexpectatus* must be nocturnal and probably carnivorous. The burrow entrance is always closed and faces the sea and the burrows average about 2 ft. in depth. They are found from 6 ft. above high tide mark to about 150 yd. inland, always in fairly loose sand. The covered entrances are quite invisible by mid-morning and the local people to whom we showed our specimens had never seen them before.

Alata with its warm climate and abundant vegetation proved a prolific collecting area and was the first locality where we found the beautiful *Nemoptera sinuata*, a distant relative of the dragonfly. It was quite common in long grass and its slow sailing flight made capture easy.

At nearby Erdemli, various species of dragonflies were collected in a marsh near the banana plantations. Not many years ago all the coast, east of Erdemli, had numerous swamps and marshes and the forests were much more extensive. But the inroads of humanity have greatly reduced these natural habitats and some of the fauna we collected is probably not far from extinction.

At Erdemli the only lizard caught has been identified as *Lacerta laevis*, which may confirm previous doubtful records from Western Turkey.

From Alata we moved to Gozne in the hills behind Mersin where at 2,500 ft. we collected for four days in sight of the Taurus still topped with snow and several times saw the Lammergeyer sailing above a gorge. Returning to Adana our journey continued to the extreme south of Turkey, to Iskenderun and Antakya and then north-east to Maras. In this area storks were demolishing an incipient swarm of Moroccan locusts which breed in the low bare hills of a wide valley. On 16th June the vegetation on these hills was already desiccated but they harboured some rare clear-winged Ascalaphids and *Olivierina extensa*.

The route back to Adana lay over the Amanus Mountains and through Osmaniye. Here, on a dull cloudy evening some 50 Hymenoptera were caught in the local cemetery, often a good collecting place in Turkey. They were all asleep, attached by their jaws to twigs and grass blades sometimes in small groups. The evening collecting of sleepy bees and wasps also proved quite successful around Ankara and elsewhere and is a good way of catching the parasites of the leaf cutter bees (Megachilidae) which are rarely seen on the wing.

After finally leaving Adana, the best collecting area on the way back to Ankara was the Sertuval Gecidi, south of Karaman. On 21st June at nearly 5,000 ft. the wild flowers were at their best and the top of the pass was swarming with grasshoppers including three species of *Poecilimon*. Near here we took a small series of the largest of the Turkish horse flies, *Therioplectes tricolor*. The Tabanidae are well represented throughout the country and on one occasion we caught 10 species flying round our vehicle.

Pontic Passes

From Ankara, which to an entomologist is a good deal more interesting than much of the Anatolian plateau, we started our second journey on 29th June. The object was to examine all the high passes that lead over the Pontic ranges down to the Black Sea Coast. In Turkey experience has now shown that the higher one goes the fewer become the insects and that above 6,000 ft. the fauna is a restricted one, though sometimes with rare or unusual species, especially among the Orthoptera. The Hymenoptera and also the Diptera become scarce at the higher altitudes and the greatest numbers of Hymenoptera are found below 3,000 ft. in the hot valleys and again at sea level. Numerically, the parasitic groups are everywhere sparsely represented and are never seen in such numbers as they are in Britain, although it can be expected that the total number of species is far higher in Asia Minor. As regards the sawflies (Hymenoptera Symphyta), the best localities were found near the wet Black Sea Coast at about 5,000 ft., although the Amasya area at 2,500 ft. is also good in May. There is still a tremendous amount to be learnt about the distribution of all the Turkish Hymenoptera and vast areas remain to be examined.

On 29th and 30th June a record number of bees and wasps was collected above the Kizilirmak Bridge near Kirikkale at the yellow flowers of an *Opoponax*, a tall umbellifer growing in fields of ripe wheat. The two-day catch totalled about 2,500 specimens belonging to some hundred species. This quantity, taken at 2,000 ft., was never exceeded and a day's catch of 500 insects to two nets was very good. On many days the total catch was only 150-200 and although each locality had something new and interesting to offer we seldom collected where numbers of species and individuals were excessive.

Our route now lay through Sivas; Zara, with its fascinating blue lake and the Karabayir Pass (5,500 ft.); Sebinkarahisar and the Egribel Pass (6,000 ft.); Erzincan, Gumusane and then to Hamsikoy below the Zigana Pass where we arrived at the inn on 12th July. The collecting on the Zigana considerably increased the number of species of Hymenoptera, especially the sawflies, that are now known from here as a result of my visit during August, 1959. But further collecting is now required during June when other but earlier Caucasian species can be expected. June is also the month in which to gather yet more of the Pontic lilies, around which obscurity still seems to cling.

Moving eastwards on 19th July we crossed the Soganli Pass in rain and thick mist and made headquarters at Bayburt. Collecting was then carried out on the drier and interesting Kop Dagi (7,000 ft.) and when the weather finally cleared we returned to the Soganli and the alpine meadows at 8,000 ft. but found the flora and fauna not very different from those of the Zigana. On 2nd August we were back in Ankara. Plans for a third journey were more ambitious; but for various reasons it seemed only a remote

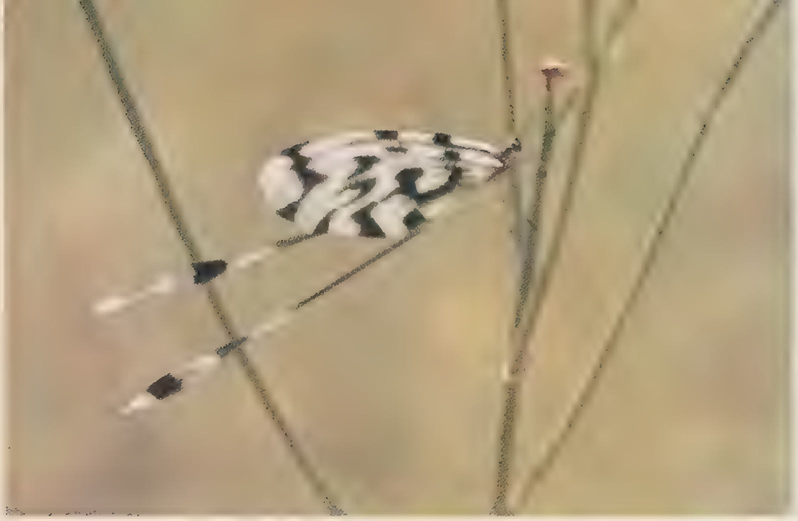
A NATURALIST IN TURKEY

Photographs taken by the author

Larva of Celerio euphorbiae, *Artvin.*

Schizodactylus inexpectatus, *Alata.*

Nemoptera sinuata, *Alata*.



Polistes *nest, near Igdir*.

Arum dioscoridis, *near Mersin in June*.

Rosa foetida, *near Ankara*.

1. Alata
2. Mt. Ararat
3. Kirikkale
4. Yalniz—cam
5. Osmaniye
6. Tuz Golu
7. Sertuval Gecidi
8. Artvin
9. Gozne
10. Maras
11. Ankara
12. Zigana
13. Kop Dagi
14. Soganli Gecidi
15. Zara

possibility until, thanks entirely to the efforts of friends at Ankara University and in the Department of Agriculture, permission was granted to visit Mount Ararat and to stay on a government farm almost on the Russian frontier. We were accompanied by Husain Belet, a member of the Plant Protection Institute at Samsun and reached Erzerum by train on 24th August.

On Ararat

The interesting discoveries on Ararat were all made below the 8,000 ft. level of this isolated, and geologically recent, volcanic mass which rises to over 15,000 ft. Very little life occurred between 8,000 and 12,000 ft., above which level we did not climb since mountaineering was not our object. The only trees seen on the mountain were those of a scattered birch forest between 8,000 ft. and 9,000 ft. but on 10th September we found nothing on them by sweeping. Lower down at about 5,000 ft. many Hymenoptera were taken on the leaves of *Ulmus* shrubs and at the flowers of a white umbellifer, *Echinophora trichophylla*. Lower still, near the Aras River which forms the frontier between Turkey and Russia, the Hymenoptera were visiting the mauve flowers of *Limonium gmelini* which occurred in bright patches between tamarisks that bordered dense *Phragmites* beds where wild pig lurked.

The flora of the gentle northern slopes of Ararat was reminiscent of North African deserts and included such plants as *Caligonum comosum*, *Tribulus terrestris*, *Aristida plumosa*, *Alhagi camelorum* and *Artemisia aucheri* all growing in sandy soil. Amongst this vegetation were found five species of grasshoppers new to Turkey.

The mystery of the identity of poisonous snakes on Ararat which frequently kill livestock was probably solved by one large specimen killed on the farm of *Vipera libetina*, which is also found in Iran and the Caucasus. The lizards collected in the area, possibly for the first time, were *Eremias velox*, *Ophisops elegans elegans*, *Phrynocephalus helioscopus persicus* and *Lacerta agilis exigua*. Two harmless snakes were *Natrix tessellata*, common by the Karasu stream, and *Eryx jaculus*, a friendly species we were loath to put into alcohol.

We were able to witness between 3rd and 10th September a marked migration of sand martins and yellow wagtails which took place every evening. A stream of birds, sometimes with flocks a thousand strong, poured across the Russian frontier and over this narrow tongue of Turkey towards the deserts and mountains of Iran. Amongst the resident birds of the mountain were the grey partridge in large coveys and in ravines and on stony hillsides the rock partridge (*Alectoris graeca*). Magpies occurred up to 9,000 ft. and choughs wheeled about the summit of the Little Ararat. Eagles of uncertain plumage were seen every day.

On 12th September we began our return journey to Ankara, via Artvin and the Black Sea Coast. We stopped once on the cold summit of the Yalnizcam at 8,000 ft., where in the short turf dotted with *Crocus vallicola* we made a notable find, a small wingless grasshopper of an unknown genus which still awaits determination.

Acknowledgment

The author wishes to thank members of Ankara University and of the Plant Protection Section of the Turkish Department of Agriculture—and equally the Shell Company of Turkey, Ltd.—for the unfailing assistance which was given at all times and in all places during the expedition.

Turrialba

THE INTER-AMERICAN INSTITUTE OF AGRICULTURAL SCIENCES

by **Adalberto Gorbitz**
Scientific Communications Service, Turrialba.

Turrialba: main building.

The Inter-American Institute of Agricultural Sciences of the Organisation of American States, located at Turrialba, Costa Rica, was designed to fill a need widely felt in Latin America—for an organisation to study the problems of agriculture and related sciences, in order to help improve the economic position of the nations which make up the southern half of the American Continent.

There are four main points to be borne in mind when considering the structure and work of the Institute. First, it is a specialised agency of an international system, the Organisation of American States (OAS), which is the oldest international institution of its kind and comprises the 21 republics of the American continent.

The second factor is the financial dependence of the Institute on the contributions from its member countries. Of the 21 states, 17 have now ratified the convention setting up the Institute. These countries contribute to its support on a proportional basis, each paying 1.25 dollars per 1,000 inhabitants.

The third point is the international nature of the technical staff of the Institute who at present are recruited from 15 American countries and include in addition representatives of other continents. This, combined with the fact that hundreds of people who have studied at the Institute are scattered all over the continent, means that in addition to the technical training and research which it organises, the Institute also fosters improved understanding between peoples of different nationalities, and contributes to a broad outlook on common problems.

The fourth factor is the central position of Costa Rica in the American continent, combined with the ecological conditions at Turrialba which make it possible to study, on the Institute's own land, many of the crops native to Latin America.

Turrialba is situated between San José, the capital of Costa Rica; and Port Limon on the Atlantic Coast, at an altitude of about 2,000 ft. The climate is typical of many areas in the tropics at a similar altitude. The average annual rainfall is 103 in. fairly evenly distributed throughout the area but with a short dry season during March and April. The average annual temperature is about 73°F.; the days are generally warm and the nights cool.

The region is suitable for the cultivation of coffee, cocoa, maize, sugar cane, rice, rubber and many other tropical crops. Although the climate is too wet for optimum production of certain fruit trees such as mangoes and avocados, it is suitable for experimental work with livestock.

The Institute has the use of a 250-acre cocoa farm situated in the hot wet tropical area of the Atlantic Coast, and is also able to carry out experimental work on several neighbouring estates situated at various heights of up to well over 8,000 feet.

Origins

At the first Inter-American Conference on Agriculture, held in Washington in 1930, a resolution was approved which advocated the creation of a Pan-American experimental station for cooperative research in agriculture, silviculture and livestock, and for the technical training of students from different countries. Ten years later, at the eighth Inter-American Scientific Conference, also in Washington, it was recommended that an Inter-American Institute of Tropical Agriculture should be set up. Following this resolution a committee was set up to study the different regions of America in order to choose a site for the Institute. Three basic criteria for the technical appraisal of the sites offered were laid down: a central position in the continent; accessibility for communication purposes;

A graduate student from Ecuador takes measurements in an experimental plot of Cordia alliodora *at the Institute.*

and easy access to a wide variety of ecological factors.

The Government of Costa Rica offered to make permanently available a sugar and coffee plantation of 1,000 hectares close to the town of Turrialba. This offer was accepted and a contract was signed at the end of 1942, between the Government and the Pan-American Union, represented by the first Director of the Institute, Dr. Earl Bressman. Two years later the Institute actually came into being, the initial finance necessary having been provided by the United States Government. Dr. Bressman remained director until the beginning of 1946, when he was suceeded by Dr. Ralph H. Allee, who continued in office until May, 1960. Dr. Allee was succeeded by Ing. Armando Samper, of Colombia, who for several years has been a senior member of the Institute's staff.

Development

The original departments were Animal Industry, Agricultural Engineering, Plant Industry and Soils, Economics and Rural Life, and the Library. Subsequently, the Department of Renewable Resources and the Scientific Communications Service were established.

The preliminary work consisted in making collections of species and varieties of various crops in order to test their adaptability and as a basis for subsequent experimental work. As regards livestock, work was carried out on the selection of native dairy cattle adapted to the tropics, and herds of beef animals were formed from the Brahman, Santa Gertrudis and Brangus breeds. Soon after the establishment of the Institute, teaching and training programmes were started, and the importance of this work has increased until it now represents more than half the activity of most of the departments. Academic studies are now carried out through the Graduate School of the Institute which coordinates the training of the various departments and confers the degree of *Magister Agriculturae*. This was the first Graduate School in Agriculture to be established in Latin America.

Over the years the work of the Institute has been supported by donations and contracts for specific purposes, which have made it possible to increase the scope of the regular services and to undertake additional projects. Examples of these special contracts are the Inter-American Cocoa Centre, which was organised in 1948 and financed with the help of the American Cocoa Research Institute; and the cooperative maize programme sponsored by the Rockefeller Foundation.

In 1955, the Institute signed an agreement with the International Cooperation Administration (ICA) of the United States Government under which it provides training facilities and consultant services to the US Operation Missions in Latin America. These services are provided in the fields of coffee, cocoa and rubber; agricultural information; agricultural advisory services; and tropical pastures.

In 1958, an agreement was entered into with the US Atomic Energy Commission by which the Institute set up a gamma ray field and a radioisotope laboratory, and so began research and training in the application of nuclear energy to agriculture. Other specific agreements have assisted the Institute in special projects such as the study of

Specimens of the tropical Criollo dairy cattle which are being developed at Turrialba.

native foods in the Andean region, the publishing of research results and educational material, and the study of the most effective methods of disseminating information.

Since 1950 the Institute has been responsible for administering Project 39 of the Technical Cooperation Programme of the OAS. This project is designed to train technical staff to a high professional level by means of short courses and using the facilities available in national organisations such as universities and experimental stations. The programme is administered through three regional offices: one for the Northern Area in Havana, Cuba; one for the Andean Zone in Lima, Peru, and another for the Southern Zone in Montevideo, Uruguay.

As its programme develops the Institute has constantly striven to achieve balance between the time, effort and resources devoted to its three main activities. First, research on the basic problems in the agricultural sciences and in the social sciences applied to agriculture which would have wide application in the countries of Latin America; secondly, the training of the agricultural technicians, extension workers, and other specialists needed by the countries of Latin America; and thirdly, the most efficient dissemination of the results of its own research work and that of national organisations in the Continent.

Individual Departments

The Plant Industry Department is concerned with problems connected with the cultivation, improvement and utilisation of tropical crops. During the past five years emphasis has been placed on consultant services to national organisations in the Latin American countries and cooperation with, and assistance to, their research and training programmes; on the training of students; and on fundamental research work which would serve as a basis for the training programme and have an application in many Latin American countries. Thus the research programme is designed to advance knowledge on certain fundamental problems; to develop or test new methods of research; and to explore special problems of particular importance in Latin America.

Examples of current work include the establishment of uniform regional yield trials of new varieties of coffee in Latin America; a corn breeding programme which utilises simplified and speeded-up breeding methods, and research on such native Latin American plants as the Andean tubers, *Oxalis tuberosa*, *Ullucus tuberosus* and *Tropaeolum tuberosum*. A research programme on the diseases of rice, in particular *hoja blanca*, has been under way for some years.

The Inter-American Cocoa Centre conducts research on the genetic improvement of cacao, with particular emphasis on the production of new hybrid varieties. Recently a series of uniform variety trials have been established under a wide variety of ecological conditions in many countries of Latin America. Research is in progress on the most prevalent disease of cacao, 'black pod', and search is being made for types of cacao which might possess resistance to this disease. Investigations are in progress on 'cushion gall', a disorder in cacao which has recently become of considerable importance in some areas of Latin America.

Additional research projects are in progress on mineral

nutrition, the insect pests of cacao and the processing of cacao for the market. Graduate students are accepted at the Cocoa Centre where, in addition to the normal programme of the Graduate School, they receive training in research methods applied to cacao. The Centre also organises a three months' short course in cacao production technology which covers all aspects of cacao growing, preparation and marketing.

The Animal Industry Department's work includes research on the improvement of native cattle by breeding in the American tropics; studies on animal nutrition; the formation of herds of beef cattle; and pasture management. As an illustration of the results achieved it has been shown that an improvement of native cattle is possible without the continual introduction of ill-adapted types from non-tropical areas. Studies have been made on hybrid vigour in crosses of native cattle with Brahman cattle. Research on the variability of the chemical composition of tropical forage crops has shown how this depends on the season, age of plant, and soil conditions. This department, too, devotes a considerable portion of its effort to its training programme.

The Department of Economics and Social Sciences deals with the study of human problems connected with agriculture. Research has been carried out on agricultural economics and rural sociology and education, so important in the application of improved agricultural practices in the field. At the present time a large part of the work of the Department is devoted to a programme in agricultural extension education. Among the immediate plans of the Department are the intensification of its research programmes, the institution of graduate training in rural sociology, and the expansion of both training and research in agricultural economics.

The Department of Renewable Resources is concerned with the preservation and proper use of forests, soils and wildlife. Although the Department was the latest one to be set up in the Institute, already among the graduates are three heads of Forestry services, five university professors, and one FAO consultant; all are currently working in their own countries. In spite of the fact that at the present time the Department has been very limited in personnel, its research work has made possible the publication of ecological maps for several countries, indicating natural climatic regions. These studies are of first importance as a basis for future work on proper land use. Another research project of the Department is a study of the use of simple vegetative characteristics of forest species, such as leaves, bark and branching, as a basis for classifying forest species.

Improved silviculture practices are under study and special attention has been paid to the introduction of species new to most of Latin America. The collection of the Department now numbers more than 80 different species, including over 30 conifers. This Department includes studies on soil and water conservation, the preservation of wildlife, and the development of national parks to contribute to the most satisfactory use of natural resources.

The Scientific Communications Service was established in 1949 to improve the facilities available for scientific communication between those working in agricultural research, teaching and extension. The work of the Department has been expanded to include training for persons working in agricultural information programmes in the different countries of Latin America. One particularly successful aspect of this programme, conducted in cooperation with the Department of Economics and Social Sciences, has been the 'ADECO' programme, which is based on the highly successful 'Train-the-Trainer' programme originated in the USA. The Department is also responsible for the editing of technical journals and other publications of the Institute. In addition an agricultural scientific communications project is providing information on agricultural research to technicians in Latin America. The service has a well equipped printing shop, a recording studio and other training facilities.

The Orton Memorial Library has a collection of more than 16,000 volumes and 60,000 bulletins. About 650 journals are taken regularly as well as more than 600 other periodical publications, such as bulletins, reports and circulars. The reference section of the library contains over 1,300 volumes. Complete bibliographies have been published on coffee, cocoa and maize, and supplements to these are issued regularly to keep them up to date. In addition to its service role to the staff of the Institute, the library offers training to agricultural librarians from the different countries of Latin America and is using every opportunity to stimulate the development and improvement of the national agricultural libraries of the continent.

The Institute is now well established and is fully prepared to fulfil its rôle as a permanent regional centre for multi-lateral aid in the field of agriculture in Latin America. It is constantly working to improve the effectiveness of its links with other world organisations concerned with agricultural development and is cooperating actively with FAO in many fields. Plans are being developed to include formal graduate training and research in the programme of the regional offices of the Institute in Lima, Montevideo and Havana and to establish regional centres. These are expected to include a centre for the temperate zone, probably based in Uruguay, another for the study of diseases and pests of banana and cacao in Ecuador, and one for the study of agricultural credit in Mexico.

A recent move has been the establishment of the headquarters office of the Institute in San José, Costa Rica. The original headquarters of the Institute at Turrialba is now known as the Tropical Centre for Research and Agricultural Training. Its acting Director is Gordon Havord, of Great Britain, formerly head of the Cocoa Centre. The headquarters office in San José is responsible for planning and programming the work of the tropical centre and of the regional offices. Provided that adequate financial support is forthcoming from the countries of Latin America, and there are encouraging indications that this support will be forthcoming, the Institute is, in the words of its Director General, on the threshold of 'a new dimension' in its activities for the benefit of agriculture in Latin America.

Schistosomiasis

A MAJOR PUBLIC HEALTH PROBLEM

Schistosome eggs in urinary deposit: large numbers of terminal spined eggs are to be seen. (Dark ground illumination.)
(Photo: Dr. D. M. Blair, Schistosomiasis Research Laboratory, Salisbury, S. Rhodesia.)

by **B. B. Waddy,** D.M., D.P.H., *Reader in Tropical Hygiene, London School of Hygiene and Tropical Medicine.*

Mankind is rapidly coming to terms with infectious diseases, whether they pass directly from one human being to another (as do smallpox, influenza, leprosy and scabies, for example) or indirectly through an intermediate host (as do malaria, sleeping sickness and many others). Of those diseases which, until recently, really frightened people and public health authorities, one can now be vaccinated against influenza and poliomyelitis, and some phase of a confident malaria eradication programme affects over 80 per cent. of those at risk to it. Amid all this progress, only a very few diseases seem to have defied all efforts to subdue them. Such are schistosomiasis, South American trypanosomiasis, and the common cold. Consequently, schistomiasis is not a particularly satisfying disease to write about. It does not even possess one universally accepted name: schistosomiasis, bilharzia and bilharziasis all have their adherents, and one finds the same tendency to confusion wherever one touches the subject. The names of the water snails which act as intermediate hosts are by no means finally settled, and treatments for the disease that apparently work well in one country prove to be actually and rapidly fatal when tried in another.

Schistosomiasis is an infection with a small worm some 2 cm. long by 1 mm. thick. The generic name is *Schistosoma*, and three main species, differing slightly in their habits, attack man: *S. haematobium*, *S. mansoni* and *S. japonicum*. The life cycles of human parasites are often adventurous in the extreme, and that of the schistosome is no exception. The adults live their long lives, perpetually *in copulo*, in the veins surrounding the bladder and rectum. Hence they can achieve posterity only by passing eggs into the outside world in the urine and/or faeces. The eggs, spined for the purpose but supposed also to secrete some proteolytic agent, burrow their way through the vesical or rectal mucous membrane, a process accompanied by some bleeding, and liable as might be expected to cause considerable discomfort to the host.

If deposited in fresh water the eggs hatch very soon, and a larval form known as a miracidium emerges, to swim around vigorously until it finds and enters a suitable snail host; those that fail to find a host die within a day. According to the most recently published authority, the hosts of *S. haematobium* can all be grouped in the genus *Bulinus*. A subgenus *Physopsis*, a name commonly used, cannot in fact be clearly distinguished, and another frequently used subgeneric name, *Pyrgophysa*, is no longer recognised (1). *Bulinus* snails are small, about 15 mm. high, and whelk-shaped. The carriers of *S. mansoni* are grouped in the genus *Biomphalaria*, once known as *Planorbis*, flattened snails seldom as much as 15 mm. in diameter. It will be observed that when, in the customary manner, the generic names are given as initials, both are *B*, which can and does add to the confusion. The hosts of *S. japonicum*, *Oncomelania* species, have not had similar name troubles.

In the snail, a process of asexual multiplication takes place, lasting at least a month (according to water temperature) and eventually giving rise to large numbers of another type of larva, the cercaria. Cercariae burst their way out of the snail, to become free-swimming, and can then survive for only about 48 hours unless they come in contact with a new mammal host, and infect him by passing through the unbroken skin. Even then their hazards are

A rice farmer in the Philippines clearing weeds from an irrigation canal, so depriving the schistosomiasis-carrying snails of food.
(Photo: WHO.)

not ended, for, before reaching their final destination as adults, they are carried passively in veins and capillaries through the host's lungs and into the liver. In one experiment, out of 30,000 cercariae introduced into a host, 20 lived to maturity.

Clearly, schistosomiasis could not exist if nobody urinated or defaecated indiscriminately in standing water. But people do, and improvement in sanitary habits sufficient to end transmission is not envisaged by even the most optimistic. Transmission would cease abruptly if nobody paddled bare-legged. But children bathe and many urinate while they do so. And farmers work in water, planting rice or, in dry countries, growing all their crops among systems of irrigation canals. Also, since the distance that the minute miracidia and cercariae can swim are very short, transmission can only continue where men and snails are concentrated together in limited areas of water. There are, in fact, many places with snail populations suitable for schistosomiasis transmission where the disease does not occur. In some, this may be because no infected traveller has yet introduced it, but in others the reason is that the human population density is insufficient to overcome the odds against the success of the fantastic peregrinations of the immature worms.

Endemic Areas

It will be appreciated that the ideal conditions for transmission occur where human and snail populations are brought together by irrigation farming or rice growing. In Africa, the home of irrigation farming is Egypt, where the levels of the annual Nile flood have been charted for thousands of years; and in Egypt the eggs of *S. haematobium* have been found in the bladder walls of mummies from 2000 B.C. It is probable that this form of schistosomiasis was a local Egyptian disease until Africa was opened up, but that it spread inexorably to any area where irrigation systems were created by developing populations to increase their food supplies. Thus, nowadays, the disease is present throughout Egypt and the Sudan, most of East, Central and West Africa, and part of South Africa. It has reached many of the oases of North Africa, and has spread up into the Middle East as far as Turkey and Persia, and even into Spain and Portugal.

S. mansoni was probably West African in origin. It has spread widely and rapidly in Africa, overlapping *S. haematobium* in many places now, and is also widespread in South America, where it must have been introduced by the slave trade. *S. japonicum* is a disease of the Far East. Apart from one small focus of *S. haematobium*, the Indian peninsula is free from schistosomiasis.

The colder the water, the less the chance of the aquatic cycle being completed. Outside the subtropics, schistosomiasis maintains itself somewhat uneasily. It is, in fact, the nearest approach there is to being a true tropical disease, and its control or eradication is comparatively easy in its European foci. But where climatic conditions suit it, with one or two exceptions there is very little to show for the millions of pounds that have been spent on control measures. In an endemic area virtually everyone is infected in childhood and, this being one of the most chronic of all infections, a high proportion continue to harbour the worms throughout life. Pick the first passing child, and

This Egyptian farm worker by standing in irrigation water runs the risk of catching schistosomiasis—still the most serious disease in Egypt.
(Photo: WHO.)

eggs will be found in his urine. Pick the first passing adult, and his bladder will show evidence of the passage of eggs over the years.

Extent of Disability

Does it matter? How much disability does schistosomiasis cause? After several thousand years of it, the Egyptians may not all present pictures of refulgent health and energy, but they are still there, and still farming. In the north of Ghana, there is a linear separation between endemic and non-endemic areas—due to a change of soil, the vector snails are not found in the latter. The writer had every school-child in both areas examined a few years ago, and compared growth and intellectual progress as between the two. There was no perceptible difference in school results, and in heights and weights the only difference was that among the oldest (12 years) girls, those from the endemic area were slightly lighter on average. (There were other differences between the areas, notably that the staple diet was grain in one and yams in the other. One cannot say that the apparent disadvantage of the 12-year-old girls was necessarily due to schistosomiasis, but it can be claimed that any marked disadvantage due to schistosomiasis should have shown up.)

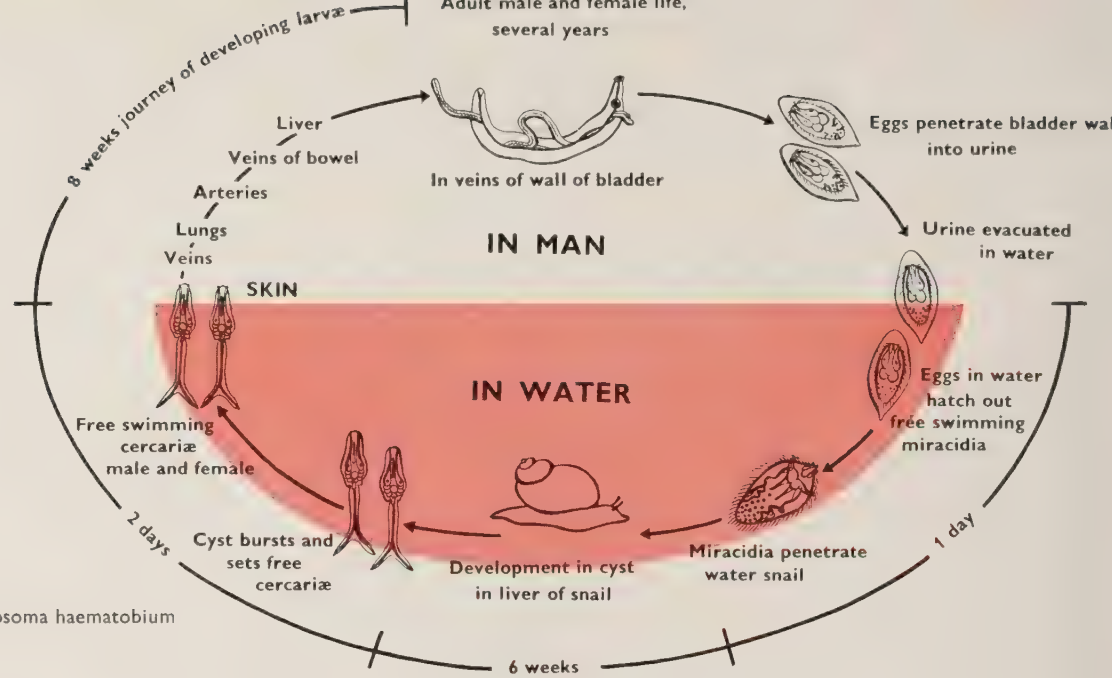
The adult, infected from childhood, takes the passage of some blood in his urine for granted and feels little, if any, discomfort. This does not apply to those who are infected for the first time as adults. During the last war a general in West Africa sent out an order that every man in his division should learn to swim, as part of their training for the Burma campaign, and refused to listen to suggestions, which the writer among others made, of the dangers of schistosomiasis. One brigade was unlucky in its choice of bathing places, and every man in that brigade was heavily infected. Many of the Africans were not seriously disabled, but the European officers all suffered fairly severe and very painful illness.

The mucous membrane of bladder and/or rectum tends to develop papillomata, and in some cases these become cancerous after many years. Scar tissue in the bladder may partly block the flow from the kidneys, with adverse effects on the latter, accelerating if not actually causing death. *S. mansoni* eggs, losing their way and passively transported by the blood stream, end up in the liver and can damage it severely. *S. japonicum* also causes liver damage, generally more severe than *S. mansoni*, and its eggs can be carried even as far as the brain, with epilepsy as a consequence.

Asiatic schistosomiasis can be recognised as a serious disease by the symptoms and pathological lesions it produces. Individual *S. mansoni* and *S. haematobium* infections sometimes cause palpably serious illness, but any attempt to assess the damage that they do to the average individual in an endemic area ends in frustration. It ought to be causing grave and visible harm; yet there is nothing on which to say that it actually does. However, the lack of evidence does not prevent almost universal agreement among the medical authorities of Africa: schistosomiasis is a public health problem standing next to malaria and tuberculosis in importance.

Control

The control of any disease with an intermediate host can



Life cycle of Schistosoma haematobium (*bilharzia*).

be attempted by any or all of three methods. First, render all present cases non-infectious by treatment, after which the disease cannot be passed on and so comes to an end. Second, break the contact between man and the intermediate host. Third, control the intermediate host: eradicate it if possible, but at least diminish its expectation of life below that necessary for the cycle of the organism concerned to be completed. The first possible difficulty is the existence of a reservoir of the disease in lower animals. *S. japonicum* readily, and *S. mansoni* appreciably, infect other mammals; *S. haematobium* hardly does. Therefore mass cure of human *S. haematobium* infections would end transmission, but mass cure would not be an effective control weapon against *S. japonicum*, and might not be effective against *S. mansoni*.

Many drugs have been developed as cures for schistosomiasis, but as yet none of them is either safe or effective enough to be used as a mass cure—as tryparsamide, penicillin, and the sulphones are used for sleeping sickness, yaws and leprosy. It will not be practicable for many years, if ever, to break contact by changing habits of urination and paddling. At present, therefore, control measures are directed against the snail.

The classical molluscicide is copper sulphate, solid crystals of which, enclosed in cloth bags, are trailed through the water so that the mineral dissolves slowly. A concentration of 20-30 parts per million of copper sulphate in water kills adult snails, but unfortunately does not kill their eggs, nor adults that have burrowed into the mud of the bottom. In fact, control by copper sulphate is of limited use, and of transient effect.

A more modern molluscicide is sodium pentachlorophenate, which is reputed to kill eggs as well as adult snails; it has the disadvantage of deteriorating rapidly in sunlight, so that the effective concentration starts to drop as soon as it is sprayed on water. Another new molluscicide has recently received favourable reports, but it did not actually eradicate the local snails in a controlled experiment. Even if it did, who is going to apply molluscicides every three or four months over the length and breadth of Africa?

A few rays of hope shine feebly but clearly through the gloom. In the Gezira, the great irrigated cotton-growing area of the Sudan, the authorities believe they have ended the transmission of schistosomiasis. Having the advantage of controlling the ingress of water from the Nile to the whole irrigation system, they set up a wire screen across it to prevent snails from getting in. The irrigation canals, cleared of the vegetation that snails like, were dealt with at leisure with copper sulphate and, since then, re-development of a population from immature snails that pass the screen is prevented by a low dose of copper sulphate, applied at the main intake and thus permeating throughout.

In an area of Tanganyika, well watered and notorious for schistosomiasis, prolonged search eventually localised *infected* snails to a very few, very small ponds—scarcely more than puddles. Have we been deluding ourselves as to the sites where infection actually takes place? Molluscicing the whole of the rivers and swamps of Africa is impracticable, but it is possible that what is required is to find and treat certain favoured pools and stream crossings—many of them, to be sure, but all essentially small so that at least economic considerations will not rule out action automatically.

For all the money and time that has been spent on research into schistosomiasis, a very inadequate return has been obtained and too much of the work has been repetitive. The problem of schistosomiasis needs new brains, to consider it afresh from new angles. It does not look very hopeful at present, but who, 20 years ago, thought in terms of the world-wide eradication of malaria and leprosy?

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Government Aid to British Agriculture

AN HISTORICAL SURVEY

by **E. G. Hancock,** *Shell Chemical Company, London.*

In this article the author gives a picture of how the attitude of the state to agriculture in Britain has varied over the centuries, with particular emphasis on the last 50 years. He shows how the struggle between the various interests involved has sometimes favoured one party and sometimes another until, now, a compromise has been reached in an effort to maintain an efficient agricultural industry in the interests of national security, of security for the farmer, and of a stable cost of living for the consumer.

The history of assistance to agriculture by British Governments can be traced back to the Middle Ages, when the Corn Laws were mainly designed to maintain an abundant supply of food at fair and steady prices, at the same time making the nation independent of foreign food supplies. Before 1800, with certain obvious exceptions, England virtually supported herself in foodstuffs. The principle established from about 1660 (the time of the Restoration) onwards was that cereals could be exported only when the home price fell below a certain figure, duty on imported corn at the same figure being substantially increased; in other words, exports were encouraged when prices were low and imports when they were high. In the time of William and Mary (1689-1702) a subsidy was paid on every ton of cereals exported when the domestic price fell below a certain figure and this led to much grassland being ploughed up.

It is interesting to note, too, that there were many restrictions on profiteering and on the activities of middlemen. Government activity in these matters was by no means confined to the most recent times.

The position continued unchanged, with minor exceptions, until 1815 when, with the end of the Napoleonic War, the Government took action to protect farmers from fluctuations in the price of cereals which were expected to take place in Europe with the aftermath of the war. Restrictions on exports were removed so that the farmers could take advantage of any shortages in European markets, while the specified figure for home market prices above which a high import duty was applied was raised from 11s. per cwt. to about 21s. per cwt. This had the effect of virtually stopping imports. United Kingdom prices now fluctuated widely according to the harvest and much hardship was caused to the ever growing industrial working population.

The position, therefore, between 1815 and 1846 greatly favoured landowners and the farming community as against the town dweller and industrial population, but it was supported by some political elements who considered that the Napoleonic War had shown it essential that the nation should be self-supporting in cereals. The opposition was headed by the manufacturing community who wanted their workers to have access to the cheapest sources of food so that wages could be kept down and their competitive position in the export market maintained. The interest of the 90 per cent. or so of the population who were the main consumers of the cereals and who lived near to the poverty line carried very little weight at this stage.

Repeal of Corn Laws

During the early 'forties, however, a series of poor harvests produced near famine conditions, and Sir Robert Peel, at the head of a Tory Government, risked splitting his party and repealed the Corn Laws. The result was that only a nominal duty of approximately 3d. per cwt. on imported corn remained. The first effect was, as might be expected, a panic amongst farmers, and prices fell between 1848 and 1850. Various factors, however, caused considerable improvement over the next few years: the discovery of gold in Australia and Canada tended to raise prices, and the International Exhibition of 1851 stimulated trade and generally caused some rise in the standard of living and hence increased demand. Further, the Crimean War closed the Baltic to Russian corn. Some good harvests helped the general prosperity of the farming community and it was found that imports were absorbed without home supplies being displaced.

During the 1860's and early 1870's it appeared that the *laissez faire* policy was proving successful. The farming community were relatively prosperous and in 1869 complete free trade was introduced by the removal of the 3d. per cwt. duty on imported corn. Prosperity was given a further lease of life by the increased exports during the Franco/Prussian War, and also by improvements which had taken place in farming techniques.

Apart from cereals, the price of wool had risen from 13d. a lb. in 1851 to 27d. per lb. in 1864, which made sheep farming more profitable, while over the same period there was a considerable increase in the cattle population. From 1874, however, a slow deterioration set in. The immediate cause of this appeared to be over-production in many countries following the end of the Franco/Prussian War, and a succession of poor harvests in the United Kingdom. The development of numerous areas of wheat in the Middle West of the United States was beginning to affect the situation by providing supplies of cheap cereals. It was beginning to become accepted, too, that food was the currency by which foreign nations paid for UK manu-

factured goods. In the 'eighties the Government took some limited action to assist the farming community: grants were provided in certain cases, measures were taken to stamp out disease in livestock and to prevent the adulteration of feed stocks, while in 1889 a Ministry of Agriculture was set up.

There was, over the years, a definite change in the trend of British farming. The availability of cheap imported corn caused a considerable decrease in arable land and farmers gave more attention to beef cattle and horticultural products, with the result that many of the previously rich wheat areas of the midland and eastern counties became little more than cattle ranches. The area under corn shrank from 8.2 million acres in 1871 to 5.9 million acres in 1901.

A Royal Commission, appointed in 1893 to enquire into the state of the farming industry, showed that farmers with ample capital and energy were pulling through, and so were many of the one-man farmers, but of the others many were either living on the poverty line or had gone in for other activities. However, beyond slight extensions of the palliatives mentioned earlier, nothing further was done.

Twentieth Century

In the early years of the twentieth century improved techniques led to some increase in prosperity and by the outbreak of the First World War British agriculture had adapted itself to the long-term effects of the *laissez faire* policy (by this time cereal imports from Canada were becoming a major factor) and, by concentrating on products that could not readily be imported, farmers were obtaining a reasonable livelihood.

The First World War produced a crisis in British food supplies but no action was taken until well on into 1915, when guaranteed minimum prices for four years for wheat were arranged, to encourage farmers to plough up grassland. The Coalition Government, in 1916, carried this further and one million acres were added to the arable land in 1917 and a further two million acres in 1918. By 1921, however, the guarantees lapsed, free trade was again in full operation and the price of wheat fell from 18s. per cwt. to 11s. 6d. per cwt., and much of the arable land returned to grass.

In 1931 the world slump caused a catastrophic fall in prices, the free trade principle was abandoned and an attempt was made to increase the quantity of home-produced foodstuffs by protective tariffs. No duty was, however, placed on wheat itself.

Meanwhile attention was being given to beet sugar to prevent the country being entirely dependent on imported sugar. The acreage rose from 8,000 to 400,000 between 1922 and 1934. Direct Government subsidies to the tune of £3 million per year were, however, necessary to protect the growing industry from the competition of improved strains of imported cane sugar.

In 1931 the Agricultural Marketing Act was passed which allowed sections of the agricultural industry to set up Marketing Boards to regulate prices and arrange collection and distribution of products. Hops were the first crops treated in this way, followed by milk, bacon, and other commodities. This brought some security to the specialist farmer.

Immediately on the outbreak of the Second World War the Government intervened in a big way. A target was set for an increase in arable land and an additional two million acres were brought under the plough in 1939-40. Farmers were urged to produce as much milk, corn, potatoes, and other crops as Government estimates considered necessary. Reasonable prices were agreed between producers and consumers. Farmers knew what they would get for their produce and that they could be certain of selling it. Besides fixed prices there were bonus payments and acreage guarantees for certain crops. In fact the farmer was virtually told what he was to produce by his local War Agricultural Executive Committee.

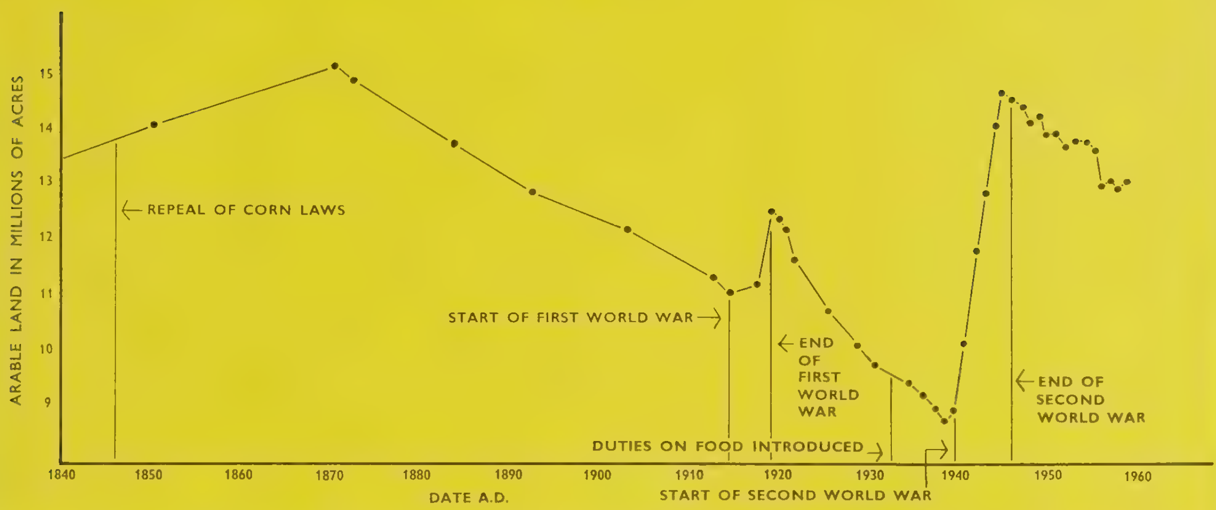
Agricultural Act, 1947

When the war ended in 1945, Britain's supplies of foreign currency were practically exhausted and imports of foodstuffs still had to be very greatly restricted. With these facts in mind the Agricultural Act of 1947 was passed, the purpose of which was to build up a stable and efficient industry capable of producing in the UK such part of the nation's food and other agricultural products as was in the national interest. The Government continued to guarantee prices and, with minor exceptions, to buy all produce covered by the Act, the Government assuming responsibility for disposing of the whole quantity on a rationing system. In an attempt to keep the cost of living down, the Government paid enormous subsidies, part of which went to the farmer and part to the consumer. This had the effect of giving an unexpected degree of security to the farming population and at the same time delayed the abolition of the rationing system, as obviously the Government could not subsidise to the ordinary consumer an unlimited quantity of foreign food.

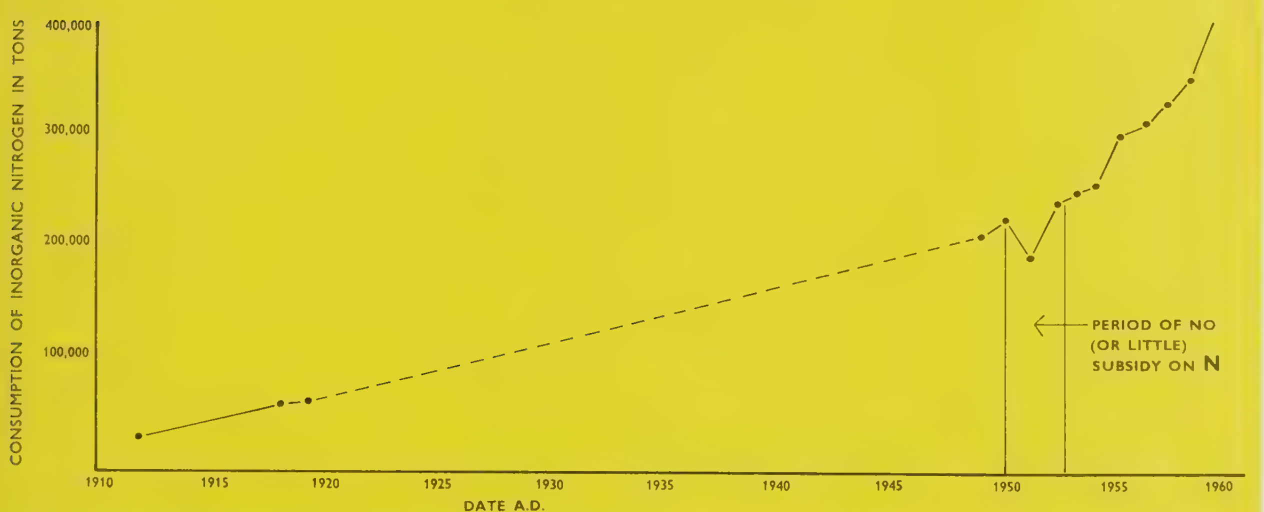
Gradually, foodstuff imports had to be resumed on something approaching the pre-war scale, mainly as a result of reciprocal agreements, for in many cases other countries could not buy British manufactured goods, coal, etc., unless Britain bought their foodstuffs, even though these might well be in the luxury class. The position was relatively straightforward while world prices remained specifically higher than the fixed prices, including guarantees, paid to the farmers. However, in 1953, the position began to change rapidly, and world food supplies could be imported at prices often lower than the price to the farmer. In 1954 the rationing system was finally abolished and subsidies to the consumer, except that on bread which was continued for a year or two longer, were finally removed.

The position at this date was that the agricultural industry in the UK was relatively prosperous; great advances in agricultural techniques had been made, and naturally the farming industry wanted to know what would be the policy of the Government under the new conditions. Quite apart from a reluctance to let down the farming community which had served the country so well during the emergency period, the Government had to take into ac-

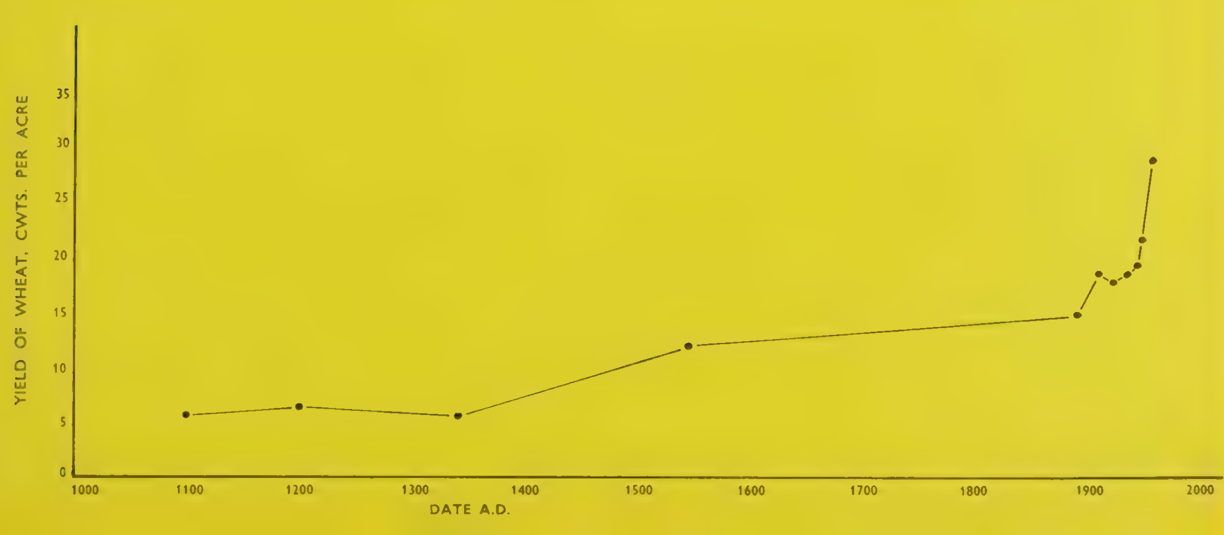
Changes in arable acreage in Britain, 1840-1960.



Consumption of inorganic nitrogen in Britain since 1910.



Wheat yields in Britain, 1100-1960.



count that twice within living memory the British Isles had been badly cut off from imports of overseas foodstuffs, and policy considerations seemed, therefore, to dictate the necessity for an efficient agricultural community in this country, producing a wide range of products.

During the 1939-45 War and for some years afterwards the Government had controlled the ex-works price of fertilisers at their 1940 rates by paying a subsidy to the fertiliser manufacturers. From July, 1949 to June, 1951 this subsidy was progressively withdrawn so that the price of fertilisers to the farmer rose substantially, and as a result their employment fell, sales dropped by 30 per cent. in the case of nitrogen and by 46 per cent. in the case of phosphorus (year 1951-1952 compared with year 1949-50). The Conservative Government, elected late in 1951, which had given pledges to 'assist' agriculture and which was alarmed at the fall in the use of fertilisers, decided to reintroduce the subsidy but in a different way, this time the money being paid to the farmer on the basis of his purchases of fertiliser at the free market price. At first this applied to phosphorus only but it was later extended to nitrogen, though not to potash. The amount of the subsidy increased until 1958-1959—thus for nitrogen it was 3s. per unit in 1952-1953, 5s. 6d. in 1955-1956 and 9s. 6d. in 1958-1959. There was, however, some reduction in 1960-1961 to 9s. but it was interesting to note that this was followed immediately by a fairly general reduction of the basic fertiliser price. During these years the consumption of fertilisers has increased very substantially and there is some evidence, particularly for wheat and barley, that the yield per acre has increased.

Annual Price Review

Returning to the general position, in 1957 there was passed an Agricultural Act which gave farmers, and to some extent suppliers of agricultural machinery, fertilisers, etc., a certain degree of security. An annual review takes place each March when the Government, in conjunction with farmers' representatives, estimates the gross turnover received by the farmer on price supported items during the current financial year. This total is made up by estimating the amount which has been received for each price supported item and adding these up. From the quantities produced an average price per unit received by the farmer is calculated and a decision taken as to whether an increase, a decrease or no change in this price is justified for the coming year. Estimating the quantity to be produced, the gross value of each item to be produced in the ensuing year is calculated, and hence by addition the total for all price supported items. Production grants are next considered, a decision is taken as to whether any changes in the individual items (e.g., the fertiliser subsidy) are justified, and the estimated costs of these for the ensuing year are totalled; this total is referred to as 'the guarantee'.

Now, according to the Agriculture Act of 1957, the guarantee must be at least 97½ per cent. of the current guarantee plus any estimated increase in costs. It will be appreciated that the figures for the current year are in themselves largely an estimate, as when the review takes place the final figures are not available. It should also be made clear that the total figure arising from the guaranteed prices does not in any way define or limit the Government's commitment; the Government's obligation is to pass over to the farmers, through the various marketing boards, the difference between this total and the total that would have been received by selling on the free market. In practice it means that a price per unit is fixed for each commodity and if the farmer cannot attain this on the free market the Government will make up the balance. Normally it is the marketing board that is selling so that the free market price is clearly defined and not subject to fluctuations depending upon local circumstances. So if, for instance, there is a very good harvest the Government may be affected in two ways:

1. A good crop means the farmers have more to sell and, with the exception of milk, the Government have guaranteed to purchase all they can supply of the scheduled products;
2. Larger quantities tend to depress the free market prices, so the difference between the price obtained and the guaranteed price is greater, and it is this difference, multiplied by the quantity produced, which decides the actual Government subsidy.

The 'guarantees' therefore in any given year do not afford much information as to what the Government are actually having to pay in subsidy.

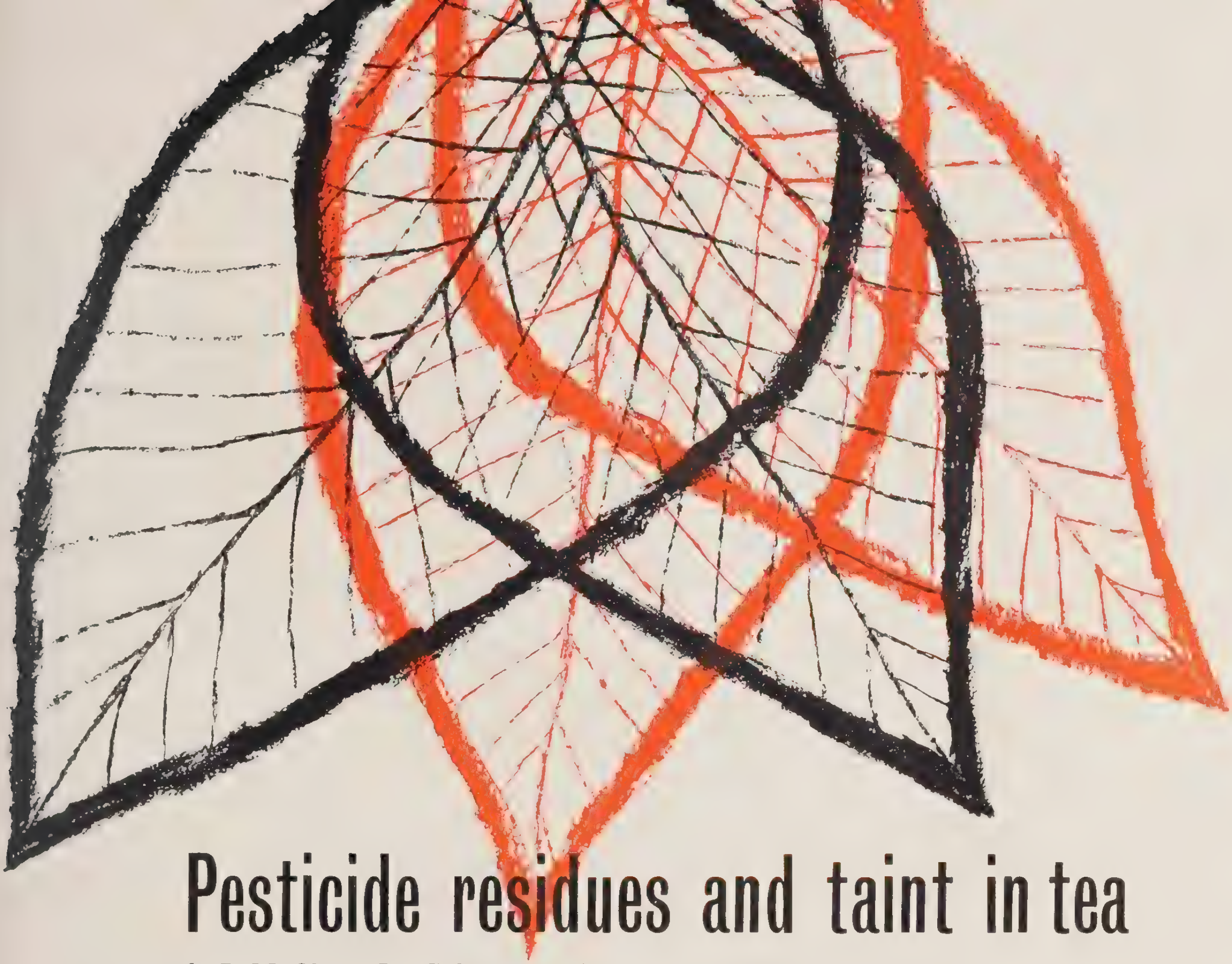
The products covered under the Act are cereals, fatstock, milk, eggs, potatoes, wool and sugar beet; contact with the producers is normally maintained through the appropriate marketing board (the British Sugar Corporation, however, deals directly with British sugar producers). Milk is also an exception to some extent in that the guaranteed price applies only to a standard quantity and sales in excess of this, normally for manufacturing milk products, reduce the average return to the producers.

In fixing a guarantee for the following year the Government takes into account the following factors:—

1. The national economic situation;
2. The Exchequer liability;
3. Relations with the Commonwealth;
4. The general prosperity of the farming industry;
5. Any trends to over-production;
6. The weather in the past season.

The Government does not necessarily reduce its support by the full amount to which it is entitled under the Act; thus for the 1958 review it was entitled to reduce the total guarantees by £21 million but did so only by £19 million; in 1959 it was entitled to reduce the total guarantees by a further £19 million but actually, mainly on account of adverse weather conditions in 1958, increased it by £3 million. On the other hand, in 1960 the total guarantee was reduced by £9 million against the £19 million permitted.

This brings the position up to date. How far it remains the policy for the future will depend upon the trends in world political conditions, the tendency of countries to draw together into economic units, the future of Commonwealth preference and the general level of tension between East and West.



Pesticide residues and taint in tea

by **P. M. Glover, Dr. G. M. Das** and **Dr. T. D. Mukherjee**
Tocklai Experimental Station (Indian Tea Association).

Tea in North-East India is subject to a large number of pests and diseases which reduce the yield of leaf produced and which weaken, and can kill, the bushes. In the past, when costs of production were low and highly effective pesticides were unknown, very little spraying of tea was done. Against the larger insects hand collection was used; against fungi the non-toxic Burgundy and Bordeaux mixtures were popular, and lime sulphur was employed against red spider.

In recent years labour costs have risen steeply, to as much as 30-40 per cent. of total garden expenditure. This and other factors have necessitated greatly enhanced yields per acre in order to lower costs of production. Greatly increased yields, together with greater appreciation of the losses caused by pests and diseases, have brought the need for controlling their ravages into considerable prominence. Such losses are in fact very large and have been estimated in round figures as 64 million pound of made tea (29 million Kg.), approximating to some 13 per cent. of the total crop produced in North-East India.

Simultaneously, the tremendous developments which have occurred in the chemical industry have resulted in a wide range of new synthetic organic chemicals, many of which are highly effective against pests and diseases at relatively low dosages. More particularly the chlorinated hydrocarbons and organophosphorus compounds have placed in the hands of the cultivator highly efficient weapons for pest and disease control. On the other hand, the very fact that such materials are very toxic, even in small dosages, poses its own problem. There is the risk of toxic materials applied to the crop being carried over to the manufactured product and becoming a danger to the consumer; there is the possibility of pesticides giving rise to taint in the manufactured product; and there is the risk to operators applying toxic materials.

To understand the implications it will be necessary briefly to describe the application of pesticide chemicals to tea in relation to cultural practice, in so far as it is relevant to these issues.

Spraying in Relation to Plucking

During the plucking season, it is at times necessary to spray the tea, and it is the usual practice (though not compulsory by statute) to apply sprays immediately following

Table 1

Distribution of rainfall at Tocklai, Central Assam, during the plucking season, April-November, 1958.

Month	*Total Rainfall*		*Number of rainy days*	*Maximum number consecutive days with no rain*
	Inches	*Millimetres*		
April	4.03	102.4	20 days	3 days one occasion only
May	15.84	402.3	28 days	2 days one occasion only
June	8.67	220.2	19 days	8 days one occasion only
July	25.32	643.1	30 days	1 day
August	15.35	389.9	31 days	O days
September	5.40	137.2	18 days	5 days one occasion only
October	6.64	168.7	15 days	6 days one occasion only
November	0.03	0.76	2 days	No spraying is done in November; 28 days very dry period

a plucking round. If plucking has been of a high standard all pluckable shoots will have been removed from the bush surface before spraying, so that there will only remain very small shoots, too small to pluck, and shoots which have arisen below, and have not yet reached, the plucking table. During the seven days between one plucking round and the next very rapid growth takes place. Small shoots left at one round will attain the size of two (and sometimes three) leaves and a bud by the next round. Shoots arising below the table may have grown into it and be pluckable, but very small buds may have resulted in shoots still too small to pluck at the next round. It should be borne in mind, too, that the majority of plucking is during the monsoon, and rain—often daily rain—between one round and the next is more than usual. This may be seen by consulting Table 1. In 1958 on only one occasion was there no rain for more than seven days except in November—when no spraying is done in any case.

The period of maximum potential danger for carry-over of residues is during tipping, where tippings are collected and manufactured; and during the second flush, and more particularly in June, when rather longer periods with no rain may be experienced.

In general, during the height of the plucking season (July-October) spraying is not common. During these months all available labour is usually fully employed in plucking. To spray involves taking labour off plucking and, consequently, loss in leaf, so that spraying during the plucking season is only a commercial proposition when the pest or disease in question is really serious.

Provided that spraying follows plucking closely, the residues left on immature shoots at any one round are enormously diluted mechanically by the growth of these shoots before the next round, and they may also be considerably reduced physically by rain. Thus, if the day of a plucking round is termed Day O, and spraying is done the same day, immediately after plucking the potential residue is at a minimum, and on D+1 is extremely small. On each day thereafter the potential residue increases until it arrives at a maximum where spraying is done on D+6, or even D+7, and no rain follows spraying. The inference is obvious, but where a pest is widespread it may not be practicable to cover the area affected on D+1 or even D+2.

Taint

One of the activities of the Research Department at Tocklai is the investigation of taints in tea that has been sprayed

Spraying tea against looper caterpillar (Biston suppressaria) *with endrin, using pneumatic knapsack sprayers.*

with pesticides. Formulations of BHC, for example, should not be used on tea in the plucking season as they invariably produce a characteristic musty taint in tea plucked even several weeks after spraying. One of the reasons why systemic pesticides have not been used in the tea industry is the danger of their altering the character of tea made from plants treated with them.

Residues

From the consumer aspect, more important, though perhaps not so widely appreciated as the fear of taint, is the danger of toxic residues being carried over from sprayed leaf to the made tea in sufficient quantity to produce a consumer hazard.

One of the most important procedures in determining whether a pesticide may or may not be used with safety is to determine whether residues remain on the crop at harvest and, if so, to what extent such residues are present and whether they present any toxic hazards to the ultimate consumer. In this respect every industry must differ, and the tea industry has its particular problems.

From the point of view of residues, tea starts at a disadvantage in comparison with many other crops, as in the first place the leaf must be harvested within seven days of being sprayed, since plucking must be on a seven-day round if teas of an acceptable quality are to be produced. Secondly, the consumable portion of the crop is not protected by skin or shell (as is the case in many crops) from direct contact with the pesticide, except in so far as buds are not fully unfurled at the time of spraying. On the other hand, the harvested material has usually undergone extensive growth since treatment and is subject to a complicated manufacturing process before sale.

Analysis of green leaf and manufactured tea for pesticide residues discloses that during manufacture any residue present is reduced by about half. Most of this reduction occurs during rolling, during which the leaf cells are distorted and broken and the cell contents expressed. Some portion of pesticide residue is removed with the leaf surface moisture which becomes mixed with the juices expressed and is lost during rolling. A certain amount also is destroyed during firing. Leaf surface moisture is often high during the rains.

It is clear, therefore, that any estimation of pesticide residue must be made on the manufactured tea and not on green leaf.

When interpreting residue data for tea two factors need to be borne in mind. First, that tea received by chest from a garden is rarely, if ever, sold in that form, as it is almost invariably blended with teas from at least two or three (and often more) other gardens, before sale. Secondly, the blended tea is not taken neat but only after infusion in a relatively large amount of boiling water and usually diluted with milk.

It is perhaps worth drawing attention here to the fact that residues carried over to the manufactured product in practice are likely to be very small, and far less than the possible theoretical figure, which would be obtained by test spraying a number of tea bushes on D+1 or D+2, plucking on D+7 and then manufacturing the leaf.

Pest Incidence

It is rare for any pest or disease to affect more than a small percentage of the total acreage of a tea estate and anything over 25 per cent. would be considered a fairly serious outbreak in North-East India. Even should infection exceed this amount, few estates hold the machinery, or could afford the labour, to spray more than 10-15 per cent. of their total acreage on any one day.

In fact, pest incidence is usually at random throughout a garden, some areas in each section being affected and some not. On a seven-day round only 14-17 per cent. of the total acreage is plucked on any one day. The outcome of this is that in most instances sprayed and unsprayed tea will usually be plucked on the same day and will be manufactured simultaneously. Further, when packing a consignment of tea it is the invariable practice to bulk together the manufacture of several days and to refire it immediately before packing.

US Tolerances

In the United States, tea may not, by law, contain residues of any pesticide scheduled as toxic, but a tolerance level may be set for residues of such pesticides provided that it can be shown (by the manufacturer or supplier) that residues resulting from application by the methods recom-

Tea growing under light (left) *and heavy* (right) *Albizzia shade in North East India. Such conditions present considerable difficulties as far as pest and disease control is concerned.*

mended are small enough to be absolutely harmless. The United States Food and Drug Administration have classified tea as a manufactured foodstuff and not as a raw agricultural commodity, as in the case of most crops.

Unfortunately tolerance levels have not yet been laid down in the USA for tea for any pesticide, which means that legally no residues of toxic pesticide, however small, are acceptable, nor will be until tolerances have been declared.

Tolerance levels have been specified individually for many toxic pesticides for other crops, and it is not unreasonable to suppose that similar tolerances could be established for tea. The manufacturers of several pesticides products are at present negotiating with the United States authorities to have tolerance levels laid down for their products specifically for tea.

The law in the United Kingdom is less specific than that in the United States, in that neither pesticides nor amounts are specified. The law, however, still allows for prosecution and confiscation of foodstuffs containing anything likely to be harmful to the consumer.

In general, provided pesticides are applied immediately following a plucking round, the chances of residues being carried over to the made tea in any appreciable quantity are very small indeed. Unfortunately, though, circumstances may on rare occasions occur where the maximum potential residue figure applies, as, for example, if spraying were done on D+4 or later and no rain intervened before plucking. The possibility of such circumstances occurring, even though remote, cannot be disregarded.

Although the use of highly toxic pesticides during plucking is not generally recommended in Assam, occasionally severe pest outbreaks may necessitate such chemicals being used. (We are prepared to recommend, for example, the use of DDT on tea in plucking under certain conditions, and also the use of copper fungicides, though these are not scheduled as toxic.)

Where a toxic pesticide does have to be used during plucking, as a precaution, the leaf of one and sometimes two plucking rounds following application should be discarded. Pest or disease attack would, of course, have to be extremely serious to justify this, as the loss of one plucking round, let alone two, would result in a considerable loss of made tea. No general recommendation can be made on these lines as it would not be possible to ensure its being implemented.

One can best summarise by repeating that usually any residue there may be on the manufactured tea which reaches the consumer is likely to be very small. In some cases, at least, the maximum probable residue has been determined and has been found to be below that acceptable for other agricultural commodities in, for example, the United States.

PLASTICS

a new aid in agriculture and horticulture

by **R. J. Collier**

Formerly of Shell International Chemical Company.

Plastic film, usually of either PVC or polyethylene, is finding new uses in agriculture and horticulture every day. This lightweight, easily transportable and easily fixed material is ideal for temporary protection of crops, which would not normally bear the expense of being protected by glass.

Rather than being considered as a replacement for glass, plastic film should be viewed in its own right, as possessing properties which are not available in other materials. Thus, because of its low cost and ease of handling it is finding an increasing use for temporary structures to protect crops from the weather. In many parts of the world low-growing crops which had previously been protected by heavy and breakable glass cloches are now being covered by plastic film supported on metal or wooden hoops. The process of laying the film can be mechanised by slinging the roll beneath a row-crop tractor and driving the tractor above the crop, the film being reeled out over hoops which have been put in place earlier. Because of the light weight of film, it can be used to cover light wooden structures and placed over such crops as flowers, which must be protected at certain times.

Plastic film is used for lining conventional glasshouses to prevent heat losses during the winter by the formation of an insulating air layer between the glass and the film; this has the added advantage of reducing the light intensity during the summer months and thereby eliminating the necessity of shading, to prevent plant scorch.

Another use for plastic film arises from the increased day-time temperatures and humidity experienced beneath it: for this reason it is often laid on top of grass and other seed to assist germination (the film also prevents damage by birds).

Unfortunately, films of PVC (polyvinyl chloride) or polyethylene become brittle after exposure to sunlight and do not normally last for more than one or two seasons; they also tend to collect dust, are liable to be torn by the wind and being transparent to infra-red rays allow greater heat losses than glass. At present it is unlikely that PVC or polyethylene film will replace glass in conventional glasshouses, although considerable progress has been made in overcoming some of the disadvantages of plastic film, such as including anti-static agents in the film, and certain films, such as those manufactured from polyesters, do not become brittle or torn for a number of years. However, the cost of these films is still too high to compete with glass for conventional glasshouses.

Black Film

To provide maximum possible life, carbon black can be incorporated with the plastic to produce a black film.

Black film laid on the soil surface as a mulch serves a double purpose: weed suppression, and, by reducing evaporation, the conservation of water in the soil. Yields of crops protected by a film mulch can be many times that of an unmulched crop. In addition, in crops such as strawberries, the mulch stops the rooting of runners and prevents the fruit from coming into contact with the soil.

Plastic film provides a very useful means of keeping certain soil fumigants, such as methyl bromide, in the soil during application.

In areas of seasonal rainfall there is often a lack of water during the dry season when it is required for irrigation and stock watering. Until recently, the cost of concrete reservoirs prohibited many growers from considering these for water conservation; but now, by using thick black plastic films to line suitably excavated areas, water can be stored in temporary reservoirs at a cost appreciably below that of a similar concrete structure. In connection with conservation, there is also interest in the use of large numbers of tiny plastic balls to float on the water surface and so reduce evaporation.

Black plastic film is used extensively in the preservation of silage; for this purpose it may be in the form of a large sleeve, which is gradually filled and then sealed at the top. The best type of film for this use is PVC, as it permits the passage outward of carbon dioxide evolved during fermentation but does not allow air to pass back into the silage.

Packaging

Black film is also used for covers for hay-stacks, bagged fertiliser, etc., as liners for irrigation ditches to prevent weed growth and water loss, and to 'force' horticultural

Moulded polystyrene flowerpots are light, almost unbreakable and being non-porous require less frequent watering than conventional clay pots.

Strawberries grown using black polyethylene sheeting are riper and larger than those grown using straw mulch.

crops such as asparagus and bulbs. A considerable market is also developing in the use of black plastic bags in which various seedlings, such as coffee, are grown, before transferring them to the fields.

Clear film is used as a wrapping material for bananas and with the increase of merchandising pre-packed vegetables, many vegetable crops are now packed in plastic bags. Plastic bags are being used in the United States to hold fertiliser, seeds, etc. Although at present they have certain disadvantages compared with multi-wall paper bags, there is no doubt that in time they will become an accepted form of packaging for such materials. Meanwhile, plastic film is used in multi-wall paper bags to make them waterproof.

Pipes

Plastic pipes for transporting water for drinking, for irrigation and for draining soils, are being increasingly used in agriculture and horticulture. The majority of pipe being used for conveying drinking and irrigation water is made from polyethylene and has the advantage over conventional pipe in that it is flexible, easily laid in the soil and does not rust. These pipes are generally coloured, as a clear pipe laid above ground encourages the growth of algae and subsequent discoloration of the pipe. Early plastic garden hose suffered from stiffening at low temperatures, but this is being overcome by altering the formulation of the plastic before extruding the pipe.

Pipes for irrigation may vary between small diameter flexible pipes which can be used to syphon irrigation water from a channel into the lower lying fields, and larger, rigid PVC pipes to transmit the water to sprinklers. Under intensive conditions, flexible pipes can be laid alongside the crops to be irrigated and water released at low pressure through pin-holes in the pipe, so that there is a continual trickle irrigation; this results in less evaporation and compaction of the soil surface than occurs with overhead sprinkler irrigation.

A particularly interesting development has been in the production of plastic soil drains, to replace conventional tile drains and various types of such PVC pipes are being developed in the USA, Finland, Germany, Holland and the UK. The development of plastic drainage should considerably reduce the cost of draining soils and there seems no reason why plastic drains should not be used as a form of sub-soil irrigation, water being pumped through the pipes during the dry season. Such sub-soil irrigation would

Plastic pipes are flexible, easily laid in the soil and do not rust.

cause of its cheapness and ease of ndling, plastic film is being creasingly used for temporary otection of crops.

Combined seed/fertiliser drill in which the feed tubes are flexible, corrosion-resistant PVC.

mean that considerably less water would be required than for conventional irrigation, as there would be virtually no loss through evaporation; in addition, there would be no compaction of the soil surface.

This technique of sub-soil irrigation has been used in arid areas: first the soil is excavated, then a lining of film is laid in the excavated area, and perforated plastic pipes are placed in the bottom of the excavation before the soil is replaced. By pumping a nutrient solution through the perforated pipes, plant growth is made possible in areas which would not normally support plants.

Dairy Uses

In the dairy industry, plastic pipes are being used to convey the milk to coolers and parts of some milking machines are being made from plastics such as nylon. Considerable thought has been given to the production of plastic milk churns and bottles, but so far no plastic has proved to be completely effective and economic for these purposes.

In the UK and other countries polyethylene-coated cardboard containers, in the form of tetrahedrons, are being marketed as a disposable form of milk container. The use of these, however, to replace the traditional heavy, noisy and easily broken glass bottle raises many difficulties. For example, all existing equipment in the milk distribution industry is designed around the glass bottle and would be expensive to replace. However, this problem is gradually being solved and a form of plastic container for milk will become increasingly common.

Plastic film is being used to wrap cheeses during their curing period. This results in a rindless cheese, with subsequent reduction of waste, and since the cheese can be made in a square shape, instead of the conventional round shape, there is a saving in packing space. These cheeses are dispatched to the distributor in the film casing, which enables them to be handled without fear of contamination.

Miscellaneous Uses

In the horticultural market large numbers of clay flower pots are being replaced by plastic pots, made from polyethylene, polystyrene and other plastics. These pots have the advantage over clay pots of being almost unbreakable and light in weight, and being non-porous they require watering less frequently; the smooth interior surface of the pots enables the plants to be lifted out easily.

The excellent heat and cold insulating properties of foamed polystyrene are responsible for its being used extensively in the construction of cold stores for fruit, meat and other perishable goods, and as roof linings in piggeries and hen houses. This material is also used to insulate bulk milk tanks.

Plastic buckets, watering-cans and tanks for knapsack spraying machines are becoming common sights on farms. These articles are light, unbreakable, and not affected by the normal chemicals used on the farm. Plastic pipes, valves and tanks have helped the spraying machinery manufacturer to cut down the weight of his machines without reducing efficiency—an important factor when considering knapsack sprayers.

Corrosion of fertiliser distributors can be even greater than that of spraying machines, and in the UK and Germany some manufacturers are treating their metal fertiliser distributors with an Epikote[1] resin based primary paint. This extremely tough paint has excellent adhesion to the metal and gives lasting protection against the chemicals normally used in this type of equipment.

For the future, it may be possible to produce a plastic-coated fertiliser to allow slow release of nutrients for crops such as forests and grass, on similar lines to the 2,4-D plastic pellets now being produced for aquatic weed control.

Other ideas are the use of foamed polyurethane as a growing medium for plants, watered with a nutrient solution, plastic bags to be fitted over fruit when small, to prevent damage by insects (when the fruit is ripe it is completely pre-packed), bearings on farm machinery that will require no greasing and replacement of certain sheet metal by re-inforced plastics (as has already happened in the case of tractor cabs). There is no doubt that eventually plastics will find many new uses on the farm and will become as familiar to the farmer as plastic kitchen items have already become to his wife.

[1]Epikote is a Shell trade mark.

The Soil under Shifting Cultivation. P. H. Nye and D. J. Greenland. Technical Communication No. 51, Commonwealth Bureau of Soils, Harpenden. 20s.

The Commonwealth Bureau of Soils continues its beneficent work and is to be congratulated on this, the 51st in its series of Technical Communications. The authors, P. H. Nye and D. J. Greenland, have accomplished a rather heroic task. Posted to West Africa they appreciated the urgent need to study the maintainance of soil fertility in humid tropical regions. 'Over 200 million people thinly scattered over 14 million square miles of the tropics obtain the bulk of their food by the system of shifting cultivation'.

Nye and Greenland observed the almost complete absence of quantitative information about the well-drained upland soils thus used and they and their colleagues set about obtaining some reliable data in spite of difficulties of securing representative samples and in spite of limitations imposed by crude analytical techniques. The enquiry was reinforced by well designed fertiliser trials located both in the humid forest and in the sub-humid savanna regions of Ghana. In addition, the authors have made a careful study of the literature and now give some 300 references catching a few good fish in their widely flung net.

As a result of this work, ably planned and consistently maintained for several years, the authors have arrived at tentative conclusions that give a coherent and plausible account of what happens to the soil when forest or savanna is cleared for cultivation and when the clearing is subsequently abandoned and allowed to re-establish its native vegetation.

Of the many technical observations one of particular interest is recorded in Table 6, which for the first time establishes the relative importance of rain wash and litter fall for the major nutrients under forest. Rain wash at Kade, Ghana, carried from leaves of high forest 196 lb/acre/year of potassium as compared with 61 lb/acre/year in the litter. Calcium, on the other hand, was only 26 lb. in rain wash as compared with 184 lb. in litter.

Valuable observations in this field were made by scientists of INEAC (*L'Institut National pour l'étude agronomique du Congo Belge*) before their work was so disastrously interrupted. We cannot be sure that elsewhere in the humid tropics painstaking and persistent scientists will succeed in gathering data that will permit revision of the estimates and tentative conclusions of Nye and Greenland. To contribute to such revision is the best compliment a new generation of scientists could offer to these authors, whose account seems all the more persuasive because they repeatedly call attention to the limitations of their data.

These limitations are severe and will perplex future investigators also. To find and to keep under observation a typical area of forest or savanna is difficult unless there is a stable and enlightened administration. If there is a stable and enlightened

administration it is only too likely that the chosen site will be required for a municipal dance hall or some other urgent civic purpose. If the chosen site escapes the town planner the surroundings may be changed.

Apart from this there are acute practical difficulties: let the reader consider how he would collect and analyse a representative sample of tropical forest soil. There are semantic difficulties: even our scrupulous authors occasionally write of changes in 'fertility' when referring to the dubious data yielded by chemical analysis. This is conventional slang and it is dangerously confusing. In general, however, this account is both readable and precise, a model of shrewd enquiry and clear exposition. It has helpful illustrations and a good index. H. GREENE.

The Grass Crop: Its Development, Use and Maintenance. WILLIAM DAVIES. Spon, London. 45s.

This book is a new edition of the original version published in 1952. The revision has been made in order to incorporate latest advances in the subject. The chapters on Ley Farming and World Forests and Grasslands have been extended and two completely new chapters, Farming Systems and Extending the Grazing Season, have been added.

Dr. Davies, who is Director of the Grassland Research Station, is, of course, a well known authority. His book is a fund of valuable knowledge, yet at the same time it is eminently readable by all who have an interest in grassland farming, either as informed farmers or as research workers.

In the first part of the book the author goes to considerable lengths to set grassland farming in its proper ecological perspective. The successful grassland farmer emerges, as Dr. Davies puts it, as a practical ecologist. His management practices are directed towards the establishment of the desired equilibrium between animal, sward, climate and soil. This position is illustrated by several interesting examples from different parts of the world.

It is not an easy task to set out clearly the effects of the various interdependent factors, yet the reader is left with the clear impression of the relationship between the needs of the grazing animal and the needs of the sward. The sheep, the beef animal, and the dairy cow are all fitted logically into the grazing pattern.

The book deals in considerable detail with modern techniques of grassland management. It is perhaps natural that these techniques should be mainly those evolved in temperate regions, particularly the British Isles. A very great deal has yet to be learned about the management of tropical pastures.

The establishment and management of leys are given comprehensive treatment. The properties of the more valuable grazing plants are described and the new chapter on extending the grazing season by use of special leys is of particular interest. The importance of nitrogen fixing legumes is given great prominence, especially clover and lucerne. In view of its drought resistant properties and its ability to restore soil structure, it is considered that even now, lucerne has yet to realise its full potentiality in Britain.

Throughout the book, the contribution made by research is abundantly clear, especially in the field of plant breeding.

For the less informed reader, some help in identifying grass species would have been useful. Also, a greater number of photographs of better quality might have been incorporated into the book with advantage.

This book is bound to intensify interest in the problems of grassland management and makes a powerful plea for a wider application of the techniques of intensive grass production. In spite of the enormous progress already made, much still remains to be done. R. C. TINCKNELL.

The Conservation of Grass and Forage Crops. S. J. WATSON and M. J. NASH. Oliver & Boyd, Edinburgh. 84s.

It is now just over 21 years since S. J. Watson published his two-volume review of *The Science and Practice of Conservation*. That work was one of the most complete and authoritative reviews that has been published on any agricultural subject. Since the book was published an enormous amount of work has been done on this subject all over the world, and in recent years the reader could be excused some misgivings about whether the review was still as reliable as it used to be—and in any case the book has for some time been unobtainable.

The book is now in circulation again in a new one-volume edition, with its references as recent as 1959. With the aid of a colleague and co-author, M. J. Nash, S. J. Watson has reviewed virtually all the world's publications on conservation since 1939, and has selected some 2,000 references to give 'an adequate if not complete coverage of the subject'. The work has been entirely rewritten, and despite its length and detail the material is easier of access than in the previous two-volume work. There are about 700 text pages, with 200 tables, and the references are grouped together in a 50-page list.

A general introduction discusses the characteristics of various crops that can be conserved, the effect of stage of growth in various crops on their composition and yield of nutrients, and on their mineral and vitamin contents. The book is then divided into three parts: Part I deals with natural and artificial drying, and Part II with ensilage. Each of these starts with a discussion of the fundamental chemistry and biology of the process, then reviews the nutrient losses that have been reported, and goes on to estimate nutrient composition. Each also includes some description of the practical aspects of the various techniques, and the evaluation of the product.

Part III is devoted to the utilisation of dried and ensiled crops, first by dairy cows, then by growing and fattening cattle, and lastly by sheep, horses, pigs and poultry. The last chapter gives a very useful summary of nutrient losses in different methods of conservation, some observations on the place of various methods in the farm economy, and some new regression estimates for the prediction of starch equivalent from crude fibre contents.

Parts I and II, on the technique of conservation, will probably be found more useful than Part III, on the utilisation of conserved crops by livestock. Here one has misgivings, because although a large amount of work is reviewed in detail, that work, the authors point out, has all too often suffered from inadequate design and method, particularly in dairy cow feeding; so that they found it difficult to draw any definite conclusions. A general criticism of this section, however, is that the authors might have taken a more critical approach. It may disappoint those whose study is the feeding of livestock for what is ultimately some economic purpose: and some specific points (such as the biological value of proteins for ruminants) are given emphasis which is hardly justified by the most recent trends in ruminant nutrition and feeding practice.

In surveying the literature on conservation techniques published since the last edition the authors have found no cause to alter their original conclusions, because much of the more recent work has been relatively superficial and some supposedly new processes are merely old ones rediscovered. One suspects that rather too often experiments are carried out to satisfy queries which a thorough review of the subject and some thought would render unnecessary. Nowadays workers in this field might claim they have some excuse for this, since to review all the literature might take much longer than to do the experiment! But neither the experimenter nor the adviser in conservation

technique can any longer make that excuse. Practically all the basic information which they require is in this valuable book.

D. S. MacLusky.

The Biology of Weeds. J. L. Harper. Blackwell Scientific Publications, Oxford. 42s.

In the past, the biology of weeds has received comparatively little attention, apart from those aspects related to methods of weed control. However, the situation is now rapidly changing and during the last seven or eight years much work has been carried out on the taxonomy, evolution, physiology and ecology of weed plants. The Symposium on weed biology convened by the British Ecological Society in April 1959 was therefore particularly valuable, in bringing together research workers in these various fields.

The publication of the full text of the papers given at this Symposium, and the ensuing discussions, under the above title has made this a useful reference work. The book is divided into various sections under the headings: The History of Weeds in Great Britain; Problems in Taxonomy and Evolution of Weeds; The Dormancy and Dispersal of Weed Seeds; Population Studies, Interference and Competition; Special Weed Problems —Autoecological Studies on Weed Species.

Each of these sections contains contributions from eminent workers and the publication can be recommended to students and workers in agriculture and botany.

A. McKechnie.

Introduction to Entomology. R. Jeannel. Translated by H. Oldroyd. Hutchinson. 63s.

Dr. Jeannel is Professor of Entomology at the Natural History Museum in Paris. One therefore approaches his book with the hope that here at last may be the long-awaited comprehensive elementary text-book of entomology which presents the subject as a study of fascinating colourful living creatures, rather than as a dreary collection of carefully martialled facts. While Dr. Jeannel does not completely fulfil this expectation he comes sufficiently close to succeeding to make this book well worth recommending as a useful elementary text book on the subject, although with the precaution that several of the chapters require some prior knowledge of biology to be fully understood.

The book is in three parts. The first part covers the general anatomy and classification of insects, dealing at length with external morphology, somewhat more briefly (and sensibly, since few entomologists require more than elementary knowledge of the subject) with internal anatomy and development, and finally with the classification of insects. The latter chapter carries classification down to the level of Orders, a brief summary of the chief characteristics of each Order being given. Dr. Jeannel has successfully avoided the chief pitfall open to the writer of a text-book of entomology, the presentation of insect classification in too great detail. This adds greatly to the readability of this book. The illustrations to this chapter are of a particularly high standard, as indeed are the illustrations throughout the book.

The second part, dealing with the biology of insects, is perhaps the best part of the book. Physiology, behaviour and social life of insects are described with a fascinating wealth of detail. This is the part of the book which most clearly fulfils the publisher's claim that the book is 'eminently readable', though its readability is reduced by a tendency to introduce unnecessarily obscure technical terms of limited application (cychrization, synaposematic, clethrophagous). The chapter on the forms of social life found in the insect world is particularly well written.

The final part of the book, dealing with palaeontology and geographical distribution is the least satisfactory part. The first and last sections on the evolution of insects and their spread over the earth are instructive, but the greater part, dealing with fossil insects is much too advanced for a book which claims to be an introduction to the subject.

Although it is not the long-awaited elementary text-book of entomology, Dr. Jeannel's work will make a useful substitute until that comes to be written. It could be improved perhaps by judicious pruning particularly in the latter chapters and one feels that in future editions space should be found for a chapter on the economic status of insects which would surely be very relevant to an introductory text book of this nature. Finally, the price would seem to merit some pruning also, since there can surely be few students who can afford 63 shillings for an elementary text book these days.

D. G. Cochrane.

Field Drainage. M. C. Livesley. Spon, London. 37s. 6d.

The content of Mr. Livesley's book has been distilled from some 20 years of practical experience of field drainage. As such it is full of practical wisdom, and is intended to guide, encourage, and sometimes restrain, farmers and landowners seeking advice on, or explanation of, drainage problems.

Mr. Livesley provides the reader with a glossary of drainage terms, and deals sufficiently with the behaviour of water in the soil to permit a clear understanding of the purposes and principles of drainage. He also describes briefly the history of agricultural drainage.

In the course of the book many minor problems are discussed in passing—how to deal with bog oak, for example, and the factors to be considered in piping ditches, or dealing with silage effluent. Attention to these matters, and others such as drainage of gateways, reinstatement of disturbed land, etc., provides clear evidence of the author's intimate practical experience of his subject. The examples he quotes in specific cases are particularly valuable, in the context of long-term work of this nature, in that the results five or 10 years afterwards have been recorded and assessed.

A main section of the book is devoted to the relationship between different soil types and their drainage requirements. These are dealt with soil type by soil type, with reference to the desirability of tile drainage, mole drainage, or combined methods; the effect of subsoiling is also considered in this context. Patterns of drainage and the planning of new layouts are discussed, and the reconditioning of old systems is dealt with. Here the importance of the historical approach becomes apparent, and advice is given regarding the tracing of lost or forgotten drainage layouts, which must not be ignored if newer systems are to work successfully.

The preparation and execution of tile drainage schemes are discussed in detail, and in practical terms, and the range of machinery available is surveyed briefly. A short but useful appendix deals with relevant data, and there is an index.

One is a little surprised at the relatively high price of this book, and this makes it the more regrettable that it should be marred by a number of minor mis-spellings and typographical and grammatical errors. Otherwise, the standard of presentation of the text and illustrations is extremely good.

Mr. Livesley states correctly 'this is not meant to be a textbook'. It is in fact a lively and instructive discussion of the aspects of field drainage which are most relevant to the agricultural community. It is a book which farmers and landowners will find most valuable, first read in its entirety, and then kept close at hand for reference and practical advice.

J. A. C. Gibb.

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